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Nursery & Market Garden Industries' - - Development Society, Limited. - -

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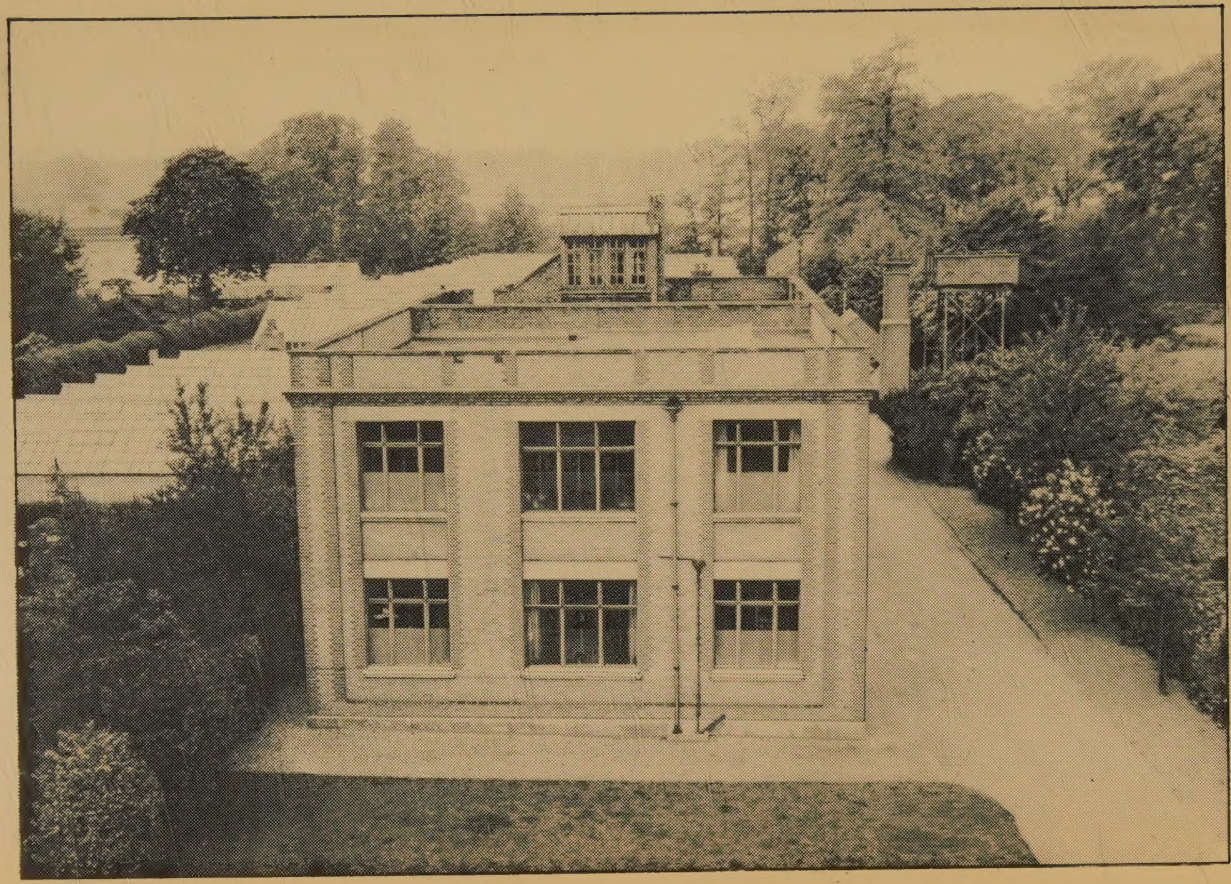


TABLE OF CONTENTS.

	Page
INTRODUCTION	7
DIRECTOR'S REPORT	17
1. EXPERIMENTAL RESULTS OF 1935:	
1. Tomatoes	17
(a) Fertiliser experiment	20
(b) Wheat straw experiment	20
(c) Variety trials	21
(d) The use of peat as a surface rooting medium ...	23
(e) "Stopping"	25
(f) Soil heating	25
2. Cucumbers	27
3. Lettuce	33
4. Cold Frames	35
2. MYCOLOGICAL INVESTIGATIONS:	
1. Rose Diseases	37
2. Diseases of Early Vegetables	42
3. A Survey of Carnation "Stem-rot" Diseases	43
4. *Verticillium* Wilt of the Carnation	46
5. A Disease of Cultivated Heaths	50
6. Virus Diseases:	
(a) General	56
(b) Two new Virus Diseases of Tomato	57
(c) Fig Mosaic	60
(d) A Mosaic Disease of Water Cress	61
(e) An instance of recovery from Spotted Wilt ...	61
(f) Some effects of Tobacco Mosaic Virus on the growth of Seedling Tomato Plants	62
3. ENTOMOLOGICAL INVESTIGATIONS:	
1. "Thrips" injurious to the Carnation Plant	63
2. Experiments in the control of *Thrips tabaci*	68
3. Rose Thrips (*Thrips fuscipennis*, Hal.)	70
4. INSECTICIDE AND FUNGICIDE INVESTIGATIONS:	
1. Red Spider Mite	73
2. Tomato Leaf Mould and Cucumber Mildew	74
3. Copper Oxychloride	74
4. Copper salicylanilide	74
5. Cuprous cyanide	75
6. Other investigations	75
7. Rose Rust	76

TABLE OF CONTENTS *(continued)*.

Page

5. CHEMICAL INVESTIGATIONS:
   1. General 79
   2. Chlorate Weed-killers 79
   3. The Potash Content of the Pulp of Blotchy Tomato Fruit 81
   4. The effect of steaming on the "availability" of potash and phosphoric acid in tomato soil 81

6. PHYSIOLOGICAL INVESTIGATIONS:
   1. The Movement of Assimilate in Seedling Tomato Plants 82
   2. A Note on Variation in Growth Rate in the Tomato Seedling 84

7. MISCELLANEOUS INVESTIGATIONS:
   Report of the Extension Officer 87

APPENDIX:
   A. Publications 89
   B. Manurial Treatments 93
   C. Manurial Treatments 94
   D. Cultural Operations 95
   E. Meteorological Records, 1935 96
   Diagram shewing arrangement of Experimental Plots in 1935

Introduction.

THE passing of 1935 marks the end of the first twenty-one years during which the Experimental Station has been in existence. The "Coming of Age" was celebrated on Thursday, June 20th, when nearly five hundred growers and other friends of the Station gathered together at 11 a.m. Luncheon was provided in a marquee erected in the grounds of the Halsey Masonic Hall, which adjoins the Station property. The President, Mr. C. H. Shoults, presided over a gathering which included many influential members of the Government, and the Ministry of Agriculture, in addition to scientists and growers well known in the horticultural world.

The Minister of Agriculture, the Right Honourable Walter Elliot, M.C., M.P., was prevented from attending by reason of important Parliamentary duties, but his place was ably filled by Sir Charles Howell Thomas, K.C.B., K.C.M.G., Permanent Secretary to the Ministry of Agriculture.

The day's proceedings included the inspection of the laboratories and the experimental houses. In addition the following growers very kindly allowed the guests to visit their nurseries, and spared no effort in explaining their methods :—

Mr. Goodwin Breeze.—Ferns.
Mr. J. Harnett.—Mushrooms, Tomatoes, Cucumbers, etc.
Mr. C. Madsen.—Carnations.
Mr. J. P. Rochford.—Grapes, Tomatoes, Cucumbers, etc.
Mr. C. H. Shoults.—Tomatoes, Grading, and Packing.
Mr. B. Stevens.—Roses.

Messrs. Geo. Monro, Ltd., also allowed the guests to visit their box making factory at Waltham Cross.

Although the weather was unkind—rain fell intermittently most of the day—the visitors expressed their pleasure and satisfaction with the arrangements.

Membership.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons. Subscriptions are payable at the rate of two guineas for each acre of glass cultivated by the subscriber; in return members receive publications and any advice which is available. Members continue to be enrolled, but many are needed, both to provide additional funds for research and to obtain complete co-operation in controlling the various pests and diseases common to glasshouse plants. Serious outbreaks over a wide area must be fought by all growers; isolated attempts to control disease are almost bound to fail.

Endowment Fund.

An endowment fund has been opened to receive contributions from those who desire to further the work of the Station. The amount collected is now £625. The capital is vested in Trustees and the interest only will be used for (*a*) future development, and (*b*) repayment of debt.

It is hoped that those who can possibly contribute to this fund will do so, and so help to secure the Station's future financial prosperity.

Bequest by the late H. O. Larsen, Esq., J.P., C.C., D.C.

Under the terms of the will of our late President, the sum of £2,000 was bequeathed to the Station. Thus Mr. H. O. Larsen, who with Mr. C. H. Shoults and Mr. J. Nielson had helped the Station so frequently in the past, performed his last act of generosity.

Current Investigations.

Manurial and crop management trials with tomatoes have been continued.

The improvement of glasshouse soils by placing clean straw in the soil to a depth of twenty inches so that the haulms are in a vertical position was tested further, by applying this material during the process of sterilizing the soil with steam. Although an increased yield was obtained during the first year after treatment it is expected that the chief benefit will be experienced during the second and later years.

An important new treatment for the purpose of improving root development of the tomatoes, and thus a means for combating root rot, has been discovered. This consists first of preventing the foliage from wilting by closing all ventilators, shading the glass, maintaining a moist atmosphere through overhead damping, and second by covering the soil with a layer of good peat. If this is kept continually moist by damping with water, new roots are produced freely from the bases of the stems, and within a fortnight new root growth is so good that the foliage does not wilt when the ventilators are fully open.

This process is being tested on nurseries in different parts of the country and should prove of great value both as a means of increasing the crop and of improving the quality of the fruit.

The effect of applying hoof and horn meal to steam sterilized soil before planting was tested and no difference in effect was noticed.

The effect of omitting phosphate from steamed soil was also investigated and as in the past no harmful result was observed either in regard to crop weight or quality.

Variety trials were continued as in the past, testing new varieties against those of proved value in commercial work.

The work on varieties resistant to *Cladosporium fulvum*, which causes leaf mould of the tomato, was continued. The types raised many years ago by crossing the resistant but poor cropping types, Stirling Castle and Up-to-date, with standard varieties such as E.S.1 have shewn marked

resistance, with considerable improvement in shape and general appearance, but the crop produced is not sufficiently heavy for commercial work. In 1933 they were again crossed with standard types. The F_2 generations grown in 1935 shew considerable promise, for the fruit is larger and the crop heavier than in past years.

The work in connection with soil warming was continued, and once again heavier crops of good quality tomatoes were obtained.

Special attention has been given to the quality of the tomatoes grown in the different experimental plots. In general, quality during the hottest parts of the year was better from the houses planted in late February than from those planted earlier. The quality was also good in the soil warming experiments and where a top-dressing of peat had been applied.

The cucumber experiments were chiefly concerned with the effect of supplying artificial light during the time the plants remained in the propagating houses. Approximately five hours' extra illumination each day was applied to different batches of plants, the light being obtained either from 500 watt gas-filled electric lamps or from Neon discharge tubes. Excellent results were obtained during the propagation stages, the treated plants being more robust and more highly developed than the untreated controls. The treated plants fruited ten days earlier than the controls and realised high prices in the market during that period. The total crop, however, shewed no increase.

The soil warming experiments with cucumbers were continued. Once again the crop was increased considerably, root development was accelerated and the plants retained their vigour until the end of the season, by which time the control beds were finished.

An attempt has been made to improve the type of cucumber at present available by raising a variety with a short neck. Although it is too early to draw any definite conclusions, the present results are promising.

Cheshunt Early Giant lettuce continues to be a valuable variety for autumn and winter work. Seeds have been distributed to nurserymen in different parts of the country and their reports will be awaited with interest.

The cultivation of salad crops in cold frames has been continued.

The importance of the correct physical state of the soil has been amply proved, and beneficial results have been obtained by mixing peat or spent mushroom beds with the soil.

The ventilation of frames has been studied and better results have been obtained by keeping the lights closed until the lettuce crop is ready for market, except after frost, than by ventilating the frames during favourable weather.

The Iron Fireman type of automatic stoker has been tested and proved satisfactory for a number of years. A second type, the Mastoker, has now been installed through the kindness of Messrs. Prior Burners, Ltd.

The "Kospa" draught regulator and fuel economiser has also been installed. This has proved a most valuable means of controlling the rate and uniformity of combustion, and is worth the consideration of all nurserymen.

A good deal of work has been devoted to a study of the bionomics of *Thrips tabaci* Lind. in relation to the carnation, and *T. fuscipennis* Mal. to the rose under glass.

Experiments in the control of these two serious pests has also been undertaken.

It has been established that *T. tabaci* lays its eggs principally in the sepals of the carnation bloom shortly before the latter opens, less often in the petals shortly after opening of the calyx. The larvæ escape from the blooms when they are full-fed, and pupate in the ground or in concealed places away from the plants. The two pupal stages are resistant to external conditions, as they will pass through these transformations and become adult while floating upon water.

It is therefore probable that numbers of the insects are distributed to nurseries in returnable market boxes. Series of plants have been dusted at intervals of three, seven, and fourteen days with Pyrethrum, but infestation of the flowers has not been reduced by this method. Repeated applications of naphthalene also had little effect in preventing oviposition, but a naphthalene fumigation rid the experimental house completely of the insect.

T. fuscipennis Hal. has been found to breed upon the young foliage of roses as well as in the opening blooms. Repeated applications of Pyrethrum dust did not reduce the infestation and made the foliage of the plants very dirty. Application of naphthalene to the plants did not lessen the infestation. Poison bait trials shewed that the insects were attracted to solutions of brown sugar rather than to those of white sugar or treacle. The insects were poisoned by brown sugar bait containing sodium fluoride, but the minimum quantity of poison necessary has not yet been determined for the experiments were seriously interfered with by the presence of a predatory bug, as yet unidentified, but probably belonging to the genus *Triphleps*. This predatory was accidentally brought into the experimental house upon blooms from outside. A bait containing brown sugar and sodium fluoride was applied to a few plants upon an infected nursery, but the foliage of the plants sprayed was seriously injured by it.

The substitution of derris insecticides for petroleum oil emulsions for the control of red-spider mite on young tomato plants has been investigated. Control has been obtained early in the season by repeated applications of derris extract and derris powder sprays. The use of dusts containing derris did not yield satisfactory results.

Further trials of oil-soluble fungicides have resulted in damage to tomato and cucumber foliage when fungicidal concentrations were employed. Several oil-soluble mercury compounds shewed high fungicidal value when tested against tomato mildew and rose rust. The damage to plants resulting from the application of oil emulsions and

salicylanilide sprays within a period of ten days of one another has been traced to the slight solubility of salicylanilide in petroleum and the penetration of the tissues by the oil solution.

The suitability of many samples of copper oxychloride for use with an oil emulsion as a combined insecticide-fungicide spray on tomatoes and cucumbers has been investigated. None of these samples yielded results as good as that obtained with a proprietary copper oxychloride suspension together with the oil emulsion.

The methods advised for the control of red-spider mite on carnations have been re-investigated and the use of high temperatures over long periods proved unnecessary. Consequently it should be possible to combat this pest without detrimental effect to the plants.

Experiments have also been conducted on the prevention of "damping off" of tomato seedlings and the control of rose rust and rose mildew.

Comparative tests have been made with mixtures which evolve hydrogen cyanide in the presence of moisture owing to the advantages they possess over the jar method of cyaniding where sodium cyanide and sulphuric acid are used.

The investigation of the rust disease of the rose have been continued. Comparative inoculations of the rose, of *Rosa laxa* and of various varieties of *R. canina*, have been made with strains of rust occurring on the rose and various briars. The form derived from the rose has not infected any of the briars tested except "Schmidts Special." Of the forms occurring on briars only one (from *R. laxa*) has proved capable of infecting the rose. The strains taken from briars shew some differences among themselves in their capacity to infect the briars tested. It is, however, impossible to find any significant differences in the size of the teleutospores when growing on the same host variety. They are, therefore, probably strains of the same species. The rose strains may possibly be a distinct species since

the teleutospores are considerably larger, but this may be due to the effect of the host and not to a difference in species.

Germination studies with teleutospores from the rose have shewn that exposure to winter cold and damp is necessary for the proper maturing of the spores. Only spores so exposed germinated, and then only during a short period in May. Attempts to infect plants with rust by means of the teleutospores during this period were unsuccessful.

The fungus reported last year as causing a wilt disease of cultivated heaths, *Erica hyemalis*, *E. nivalis*, and *E. willmoreana*, has been identified as *Phytophthora cinnamomi*. The source of infection has been traced to the water supply and standing out ground : control measures have been recommended.

Plants suffering, or suspected of suffering, from virus diseases continue to be received for examination, and during 1935 several diseases either new to the country or not previously recorded at Cheshunt were investigated. These include two new diseases of the tomato. It is proposed to call one "Bushy Stunt" and the other is a disease characterised by the "fern-leaf" type of symptom, but the causal virus is distinct from *cucumber virus* 1. Mosaic diseases of fig and watercress have also been studied.

An investigation of the effect of tomato mosaic virus on the growth of seedling tomato plants was completed.

The work on lettuce diseases has been continued in relation to attack by *Bremia lactucæ* and another disease with which the presence of bacteria is associated.

The investigation of Crown Rot in rhubarb has not disclosed any relationship between this disease and manurial treatment, but the extent of crown rot appears to be connected with the time of planting. Exposure of the plants for several weeks before planting increases susceptibility to infection.

Investigations of the *Verticillium* wilt disease of carnations have been continued. Further evidence that the disease is transmitted from crop to crop via the cuttings has been obtained. A surprising result has been failure to infect asters as these plants are reputed elsewhere to be susceptible.

Attempts to infect chrysanthemums have also been unsuccessful and this crop may prove to be of value in replacing carnations in badly diseased soil. Carnation diseases caused by *Rhizoctonia*, and various species of *Fusarium*, have also been studied. The number of inquiries from growers concerning carnation diseases reveals an urgent need for the erection of a carnation house where control measures can be tested systematically.

The physiological studies on tomato seedlings, variety E.S.1, having eight or nine leaves have been continued. An estimate has been made of the total light energy falling on the plants during the period of growth from seed to eight leaves.

Two important results have been obtained. The first result shews that there is a marked falling off in the photosynthetic efficiency (amount of dry matter produced per unit of light) as the light intensity and day length increase. The second result is to shew that the so called "seasonal" differences observed between seedlings grown from sowings made at different times of the year are, under ordinary cultural conditions, more closely related to light than to any other variable factor, and further that the total amount of light falling on the seedling during its growth period is more important than the day length.

A preliminary study of the movement of assimilates in the plant has been carried out and it has been shewn that contrary to the usually accepted view that most of the assimilate is removed from the leaf system during the night, the greater part of the movement of assimilate from the leaf system to the stem occurs during the light period and that never more than 20%, usually much less, of this movement occurs during the night. The most important

change taking place in the plant during the night appears to be one in the water balance, although movement of assimilate from the stem to the root is shewn to continue.

The percentage of assimilate which passes from the leaves to the stem and root in twenty-four hours is shewn to be at a minimum in summer and a maximum in winter, the winter maximum tending to throw the plant out of balance by the supply of a relatively large fraction of the assimilate to the root at the expense of the leaves.

A critical investigation of the movement of assimilate within the leaf system, *i.e.*, from relatively mature leaves to embryonic leaves and flower buds is in progress.

A case of chlorate injury to chrysanthemums was investigated. It appears, also, that the winter cherry and dahlia are highly susceptible to chlorates, being almost as susceptible as tomato plants. Antirrhinums and heaths shew a comparatively high resistance, but broad bean, aster, nasturtium, cineraria, and wallflower are all susceptible. In general it must be repeated that the greatest care should be taken in the use of chlorate weed killers.

Of a number of fertilisers which have been analysed one nitrogenous compound was offered at a price very considerably in excess of its manurial value.

The possibility of treating water or soil to overcome the injurious effect of an excess of salt has been explored, but with no useful result.

A preliminary study shewed that steaming has but little effect on the availability of phosphoric acid in the soil as determined by solubility in 1% citric acid. The availability of soil potash, however, appears to be definitely increased.

DIRECTOR'S REPORT.

1. Experimental Results of 1935.

1. Tomatoes.

The year 1935 has proved a difficult one for many nurserymen. Weather conditions during January, February, and March were of such a nature that the latest-sown seedlings grew very rapidly and caught up with the earlier batches. Also growth was so rapid that most growers planted in the houses much earlier than usual. The results were unsatisfactory because many of the early planted crops were attacked by root rot in April and May, and also market prices during May were much less than usual and even less than those of June. For many this meant that the increased cost of producing an early crop was not balanced by correspondingly high prices at the time of marketing the produce.

The lessons to be learned from the experience of 1935 are first that planting too early for local conditions is always accompanied by risk, and secondly that slow, steady, and not too robust growth during the early stages is necessary for the production of heavy crops of high quality fruit.

The practice of grading the tomato fruits from the experimental plots adopted in 1921 was continued during the present season.

A.—"Pinks" number 5 to 7 and "Pink and White" 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour; "Pinks" being slightly larger than "Pink and Whites."

B.—"Whites." These fruits are of good colour but smaller than "Pink and White."

C.—"Blues." This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.

D.—"Roughs." Small mis-shapen fruits about the size of cherries.

E.—Blotchy fruits which ripen irregularly.

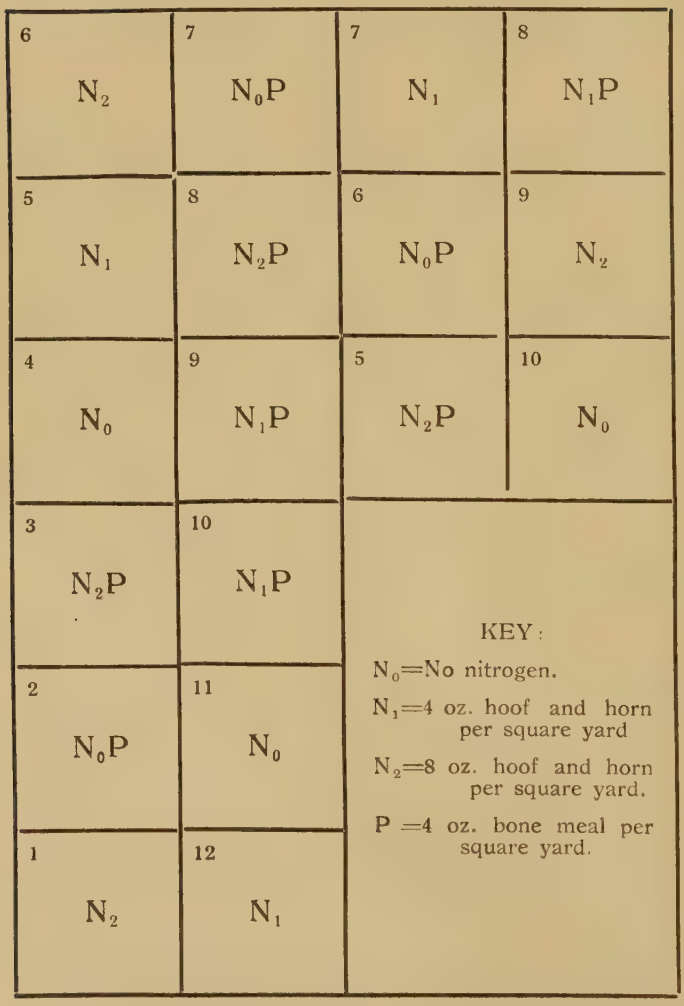
F.—Fruits shewing Blossom End Rot.

G.—Fruits shewing the lesions of Stripe Disease.

H.—Fruits shewing "Green Back."

Figure 1.

Shewing plot arrangements in houses 3 and 4.



Variety—"Ailsa Craig." **Table 1.**

House	Plot	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Total		
3	4	Soil Steamed	0.04	2.08	2.06	0.84	0.29	—	5.31	40.35	38.65
	11	,, ,, ...	0.01	1.85	1.95	0.82	0.28	—	5.01	38.06	
4	10	,, ,, ...	0.16	2.09	1.47	0.87	0.35	—	4.94	37.54	
3	5	,, ,, then 4 ozs. Hoof and Horn per sq. yd.	0.02	1.97	1.75	0.96	0.38	—	5.08	38.60	39.21
	12	,, ,, ,, ,, ,, ,,	0.04	1.88	1.97	0.97	0.32	—	5.18	39.37	
4	7	,, ,, ,, ,, ,, ,,	0.08	2.09	1.63	0.90	0.52	—	5.22	39.67	
3	1	,, ,, then 8 ozs ,, ,,	0.09	1.97	1.90	0.88	0.49	—	5.33	40.50	37.64
	6	,, ,, ,, ,, ,, ,,	0.01	1.89	1.80	0.78	0.53	—	5.01	38.07	
4	9	,, ,, ,, ,, ,, ,,	0.14	2.00	1.22	0.80	0.36	—	4.52	34.35	
3	2	,, ,, then 4 ozs. Bone Meal ...	0.03	1.89	1.75	0.77	0.22	—	4.66	35.41	38.85
	7	,, ,, ,, ,, ,, ,,	0.06	2.02	1.85	1.01	0.47	—	5.41	41.12	
4	6	,, ,, ,, ,, ,, ,,	0.11	2.31	1.63	0.89	0.34	—	5.28	40.12	
3	9	,, ,, then 4 ozs. Hoof and Horn and 4 ozs. Bone Meal per sq. yd.	0.01	2.02	2.00	0.83	0.26	—	5.12	38.91	37.99
	10	,, ,, ,, ,, ,, ,,	0.01	1.74	2.00	0.91	0.31	—	4.97	37.76	
4	8	,, ,, ,, ,, ,, ,,	0.09	1.88	1.58	0.84	0.52	—	4.91	37.31	
3	3	,, ,, then 8 ozs. Hoof and Horn and 4 ozs. Bone Meal per sq. yd.	0.05	1.91	2.03	0.81	0.36	—	5.19	39.44	39.06
	8	,, ,, ,, ,, ,, ,,	0.04	2.01	1.67	0.82	0.43	—	4.97	37.76	
4	5	,, ,, ,, ,, ,, ,,	0.17	2.39	1.55	0.92	0.33	—	5.26	39.97	

(a) Houses 3 and 4. Fertiliser experiment.

The soil in these houses was sterilized by the grid process, and an experiment was devised to test the effect of applying nitrogen in the form of hoof and horn and also phosphate as bone meal after steaming.

The layout of the experiment was arranged in consultation with Mr. F. Yates, of the Statistical Department of Rothamsted Experimental Station, to whom we are greatly indebted also for examining the results statistically. The plot arrangement is illustrated in Fig. 1, and the results given in Table 1. It will be seen that while some plots received 4 ozs. and 8 ozs. hoof and horn per square yard respectively, others were left without any added nitrogen. Also certain plots were given a dressing of bone meal at the rate of 4 ozs. per square yard, while this was omitted from others. The results shewed an error of 5% per plot, which is reasonable, but the total weight of crop produced from the plots give no indication of any increase in yield as the result of adding either the hoof and horn or the bone meal.

This confirms previous experiments relating to the use of phosphate for the tomato, and is also in keeping with results obtained on many nurseries where applications of nitrogenous fertilisers after steam sterilization have proved unnecessary, and in many cases harmful.

In these experiments no difference in quality could be detected in the fruit picked from the different plots, and it seems safe to conclude (1) that the application of hoof and horn to steamed soil before planting is without effect during a sunny summer (during dull summers it may lead to excessive leaf development), and (2) that the addition of phosphate is unnecessary.

(b) Wheat straw experiments.

The investigations relating to the effect of applying clean wheat straw to glasshouse soils was continued in houses 1 and 2. Unfortunately the plants in both houses suffered from a bad attack of root rot, which was so common on commercial nurseries in 1935, and the crop weights are less than might have been expected. While adverse weather conditions in the spring no doubt contributed to this attack, it was in part due to the fact that the plants were planted as early as February 11th.

In house 1 the soil was steam sterilized during the autumn of 1934. In plots 1—4 straw was applied with the haulms in a vertical position during steaming, while plots 5—8 were left

without straw. Although the beneficial effect of the straw should be noticeable chiefly in 1936, it proved helpful during the year under review.

The results were as follows :—

House.	Plots.	Treatment.	Average crop in tons per acre.
1	1—4	Straw applied during steam sterilization	36·18
1	5—8	Soil steamed without straw	31·39

The experiments in house 2 have now been in progress since 1933 and the following is a summary of the results obtained :—

Table 2.

House.	Plots.	Treatment.	Average yield in tons per acre 1934.	1935.
2	1—4	Straw 1933 and 1934, Steamed 1935	36·75	40·83
2	5—8	Straw 1933 and 1935, Steamed 1934	46·70	32·57

The above results indicate that so far as the soil in these houses are concerned, steam sterilization produces a better effect than does the application of straw. The straw treatment has greatly improved the physical state of the soil in both house 2 and house 3, but the effect of its application is not so great as that obtained on certain nurseries, where the soil is heavier.

Many growers have co-operated with the Station by testing the method on their own nurseries. The results are somewhat conflicting, but generally speaking they have been excellent on heavy land previously well manured for a number of years. The results vary on average soils, but the treatment is not advised for poor, light soils.

The investigation will be continued.

(c) Variety trials.

The variety trials were continued in house 5, and part of house 1. They included the trial of certain new crosses (F_2 generation) which had been made in 1933 in an attempt to produce a good early tomato. The results are given in Table 3. As in the previous year the heaviest cropping variety proved to be "J.H.," a cross between Potentate and Riverside Favourite raised by Mr. J. H. Harnett, of Hoddesdon.

The F_2 generations of the crosses made in 1933 shewed good promise and selections have been made for future use.

Table 3.

Variety Trials.

Variety	Crop Yield in Lbs. per Plant						Total Tons per Acre	Quality of Fruit: Percentage in Grade			
	May	June	July	Aug.	Sept.	Total		A.	B.	C.	D.
"J.H." (Potentate × Riverside Favourite)	0.30	3.24	1.71	0.84	0.33	6.42	48.80	52	8	28	4
Bides Recruit × Kondine Red (F_2) ...	0.50	2.53	1.61	1.08	0.34	6.06	46.05	70	17	6	4
"J.H." Sport	0.30	2.86	1.02	0.80	0.70	5.68	43.20	71	8	14	3
Potentate × Radio (F_2)	0.36	2.47	1.06	1.02	0.33	5.24	40.57	69	18	7	4
Norduke IV.	—	1.90	1.67	1.15	0.56	5.28	40.12	70	16	11	2
Radio × Potentate (F_2)	0.32	2.41	1.86	0.52	0.12	5.23	39.78	42	15	34	4
Blaby × Potentate (F_2)	0.06	2.32	1.43	1.05	0.21	5.07	38.53	52	13	26	5
Ailsa Craig (1)	0.10	2.70	1.10	0.93	0.15	4.98	37.84	67	20	7	4
Beauchamp (Miller)	0.05	2.73	1.29	0.78	0.12	4.97	37.72	65	19	12	4
Radio	0.37	2.16	1.43	0.88	0.12	4.96	37.72	66	26	1	5
K.C.B.	0.37	2.25	1.04	1.08	0.16	4.90	37.27	71	24	1	3
Best of All	0.13	2.46	0.90	1.14	0.17	4.80	36.48	62	12	21	2
Ailsa Craig (2)	0.15	2.23	1.57	0.71	0.09	4.75	36.13	56	23	14	3
Mayland Beauty Improved	0.06	2.32	1.02	1.00	0.18	4.58	34.87	65	20	2	7
Bides Recruit × Potentate (F_2)	0.02	1.60	1.95	0.63	0.27	2.47	33.97	60	18	12	4

The new leaf-mould-resisting crosses were grown in part of house 1. Resistance has been retained, the fruit is larger than in the old types and the cropping power has been increased. Further selections have been made for cultivation in 1936, when it will be possible to estimate the true value of each.

(d) The use of peat as a surface rooting medium.

The soil in houses 11 and 12 had reached the stage when steam sterilization was necessary before planting the 1935 crop, but owing to pressure of work it was decided to defer this for another year and test the effect of top-dressing the soil with peat. Manurial and other treatments were in accordance with the usual practice at the Station.

The young plants grew steadily and gave promise of producing a good crop until the end of April, when the plants in house 11 commenced to wilt. Examination of the roots shewed the presence of common root rot in a fairly advanced condition. At this stage remedial methods discovered in 1934 were applied.

The glass was shaded with flour and water, the ventilators were closed and the plants damped overhead with water three or four times each day. This produced the desired effect, for the plants ceased to wilt. A dressing of Sphagnum peat at the rate of 10 tons per acre, forming a layer $1\frac{1}{2}$ inches thick, was applied to the surface. Once in position it was thoroughly wetted with water and maintained in a moist condition by damping it each day through a fine rose placed in the end of a hose. In house 12 no signs of wilting appeared and this house was left to receive normal treatment as a control.

Five days after applying the peat new roots could be seen growing from the stems of the plants and entering the moist peat. In fourteen days root growth in the peat had advanced sufficiently to maintain the plants in a turgid condition when damping was reduced to one application each day and full ventilation was given.

The roots continued to grow in the peat until the whole layer was matted together with a mass of clean white fibrous roots. Light dressings of an organic fertiliser were given on top of the peat and the plants remained healthy until the end of the season. The quality, too, was exceptionally good.

Similar treatment was given in house 7, where in addition to root rot a severe eelworm attack developed. In this case the roots were so badly diseased that without the treatment

Table 4.

Variety—E.S. 1.

House	Plot	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Total	
11	1	Top dressed with Peat on May 7th ...	0.21	1.58	1.57	0.94	0.44	0.37	5.11	38.91
,,	2	,, ,, ,, ,, ,, ...	0.18	1.42	1.52	0.95	0.48	0.43	4.98	37.84
12	1	Control: Not top dressed with peat...	0.02	0.34	2.24	0.62	0.46	0.48	4.16	31.59
,,	2	,, ,, ,, ,, ,, ...	0.02	0.38	2.16	0.74	0.52	0.52	4.34	32.96

the plants must have quickly died. Following the application of peat, root growth became so active that despite the fact that the original root was almost useless, the plants yielded an average crop over the whole house of 42·38 tons per acre.

In the case of houses 11 and 12, the results are given in Table 4, where it will be seen that the house treated with peat gave an average crop of some 38 tons per acre, while the crop in the untreated house averaged 32 tons per acre.

The peat treatment has proved so beneficial that it is hoped it will be tried by many nurserymen, especially where root rot is common and where the top crop fails.

(e) "Stopping."

The chambers in house 6 were employed in connection with an experiment on "stopping," the variety E.S.1 being used. The plants in chambers 1 and 4 were grown on without "stopping." In chambers 2 and 5 the plants were "stopped" at the fifth truss, and then the top shoot which developed later was pruned to one stem, while in Nos. 3 and 6 the plants were stopped and all the top shoots were allowed to develop, being so tied to the wires that they were evenly spaced.

The experiment was undertaken because it is sometimes claimed that heavier crops can be obtained by allowing a good growth of shoots on the top than by retaining one central shoot.

The results given in Table 5 do not prove this, however, for while the crop weights from the "unstopped" plants and those pruned to one top shoot were approximately the same, the yield from those which were "stopped" and then allowed to produce as many shoots as they could was definitely lower.

(f) Soil heating.

The investigation of soil heating was continued in houses 7—10, the experiment of 1934 being repeated. The soil temperature in houses 8 and 9 was raised to 65°F. before planting and was increased to 70°F. when the first truss had set. It was again raised to 80°F. when the second truss had set and kept at this for a period of twelve weeks calculated from the time of planting.

Houses 7 and 10 were left unheated as controls. Unfortunately root rot, following infection by the tomato root eelworm and various soil organisms associated with this condition developed early in April in house 7 and the plants would have died quickly if the peat treatment described on page 23 had not been applied. So successful was this treatment that an

Table 5.

Variety—E.S. 1.

House	Chamber	Treatment	Crop Yield in Lbs. per Plant.					Total Tons per Acre	Average Tons per Acre
			June	July	Aug.	Sept.	Total		
6	1	Grown on without stopping	1.84	2.10	1.52	0.51	5.97	45.37	45.41
,,	4	,, ,, ,, ...	1.94	2.39	1.09	0.56	5.98	45.45	
6	2	Stopped at 5th truss then pruned to one stem	2.03	2.05	1.48	0.55	6.11	46.44	46.36
,,	5	,, ,, ,, ,, ,,	1.98	1.90	1.40	0.81	6.09	46.28	
6	3	Stopped at 5th truss and then all shoots allowed to develop	2.05	1.86	0.95	0.28	5.14	39.06	41.88
,,	6	,, ,, ,, ,, ,,	1.26	2.38	1.44	0.80	5.88	44.69	

average yield of approximately 42 tons per acre was obtained in this house, which is higher than the crop from houses 8 and 9 where the soil was heated.

The sudden wilting of the plants in house 7 reflects credit on the process of soil heating, because it provides confirmation of previous results which shewed that root rot does not develop quickly in warmed soil.

Verticillium wilt of tomatoes was very prevalent in 1935, and it occurred in houses 8 and 9, where the soil remained at temperatures below 70°F., for several weeks. The infected plants recovered when the soil temperature was raised to 80°F., but the injurious effect returned when soil heating stopped. This reduced the crop yield, because a large proportion of the plants died during the middle of the season.

By comparing the average crop in houses 8 and 9 with that from the unheated control house 10, Table 6, it will be seen that the increase due to soil warming is only about 14%. This is much less than usual, but is due to the incidence of *Verticillium* wilt in houses 8 and 9.

The experience suggests that where the fungus *Verticillium albo-atrum* exists in the soil, its temperature must be raised to at least 75°F. before planting, and some method for preventing a too rapid growth of the young plants must be devised. This can be done by keeping the plants in the size 60 pots until the first truss is extended and the first flower open. The plants should be on the hard side and may be fed in the pots if necessary.

When plants of this type are planted in warm soil, the first and second trusses set quickly. The swelling of the fruit prevents the plants from growing too rapidly and so a correct balance is maintained.

The experiments during 1936 have been arranged to demonstrate the effect of planting a small plant in soil at 60°F. and gradually increasing the soil temperature in contrast to that of planting a larger plant in soil at a temperature of 80°F.

2. Cucumbers.

The cucumber investigations included further trials with soil heating and experiments with electric light during the propagating stage.

(a) Soil heating.

It will be remembered that the trials conducted in 1934 gave exceptional results because an increased yield was not obtained by warming the beds. It was suggested that this

Table 6.

Variety—E.S.1.

House	Plot	Treatment	Crop Yield in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Total		
7	1	Soil unheated : top dressed with peat as a rooting medium to combat root rot	0.97	2.29	1.59	1.38	0.33	6.56	49.86	
	2	,, ,, ,, ,, ,, ,,	0.87	2.14	1.25	1.66	0.29	6.21	47.20	
	3	,, ,, ,, ,, ,, ,,	1.00	1.78	1.35	1.59	0.30	6.02	45.75	
	4	,, ,, ,, ,, ,, ,,	0.33	1.32	1.27	1.74	0.60	5.26	39.98	
	5	,, ,, ,, ,, ,, ,,	0.61	1.58	1.08	1.59	0.49	5.35	40.66	42.38
	6	,, ,, ,, ,, ,, ,,	0.71	1.53	1.01	1.36	0.42	5.05	38.38	
	7	,, ,, ,, ,, ,, ,,	0.85	1.63	1.08	1.34	0.35	5.25	39.90	
	8	,, ,, ,, ,, ,, ,,	0.68	1.60	1.12	1.26	0.25	4.91	37.32	
8	1	Soil heated. Planted at soil temperature 65° F. Temperature gradually raised to 80 F. ...	0.81	1.70	1.57	1.17	0.17	5.22	39.67	
	2	,, ,, ,, ,, ,, ,,	0.76	1.63	1.40	1.19	0.22	5.20	39.52	
	3	,, ,, ,, ,, ,, ,,	0.76	1.82	1.44	1.25	0.32	5.59	42.48	
	4	,, ,, ,, ,, ,, ,,	0.52	1.69	1.11	1.16	0.34	4.82	36.63	
	5	,, ,, ,, ,, ,, ,,	0.36	1.89	1.47	1.35	0.44	5.51	41.88	40.35
	6	,, ,, ,, ,, ,, ,,	0.51	1.64	1.54	1.14	0.47	5.30	40.28	
	7	,, ,, ,, ,, ,, ,,	0.72	1.51	1.59	1.21	0.27	5.30	40.28	
	8	,, ,, ,, ,, ,, ,,	0.79	1.58	1.67	1.30	0.20	5.54	42.10	

Table 6 *(continued).*

House	Plot	Treatment	Crop Yield in lbs. per plant.						Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Total		
9	1	As house 8	0.70	1.69	1.62	1.13	0.36	5.50	41.80	39.80
	2	,, ...	0.43	1.58	1.47	0.99	0.35	4.82	36.63	
	3	,, ...	0.43	1.88	1.50	1.00	0.44	5.25	39.90	
	4	,, ...	0.14	2.09	1.49	1.21	0.56	5.49	41.72	
	5	,, ...	0.19	2.02	1.54	1.29	0.50	5.54	42.10	
	6	,, ...	0.18	1.79	1.41	1.37	0.36	5.11	38.84	
	7	,, ...	0.39	1.67	1.66	1.03	0.30	5.05	38.38	
	8	,, ...	0.47	1.69	1.67	1.06	0.24	5.13	38.99	
10	1	Control : soil unheated	0.37	1.55	1.55	0.76	0.22	4.45	33.82	35.17
	2	,, ,, ...	0.26	1.52	1.55	1.00	0.23	4.56	34.66	
	3	,, ,, ...	0.25	1.71	1.46	1.01	0.31	4.74	36.02	
	6	,, ,, ...	0.18	1.74	1.25	1.03	0.46	4.66	35.42	
	7	,, ,, ...	0.21	1.53	1.41	1.14	0.26	4.55	34.58	
	8	,, ,, ...	0.25	1.67	1.58	1.04	0.27	4.81	36.56	

Table 7.

Variety—"Butcher's Disease Resister."

House	Plot No.	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre		Total Flats per Acre
			March	April	May	June	July	Aug.	Total			
C	1	Propagated under Neon lamps (a)	7.62	10.18	8.70	7.62	11.06	5.80	50.98	76.47	76.70	1.53
	3	" " " "	8.30	9.61	8.83	9.10	10.96	4.48	51.28	76.92		1.54
	2	Propagated under Gas-filled lamps	8.00	11.60	10.90	10.80	11.51	5.50	58.31	87.47	80.80	1.75
	4	" " " "	8.42	9.69	9.90	7.23	9.77	4.41	49.42	74.13		1.48
D	2	Propagated under Gas-filled lamps	11.30	10.65	9.63	8.34	13.09	5.07	58.08	87.12	83.82	1.74
	4	" " " "	9.66	9.96	9.60	9.63	12.11	2.71	53.67	80.51		1.61
	3	Controls	8.45	11.34	10.25	10.16	12.25	4.31	56.76	85.14	84.53	1.70
	5	"	9.61	10.00	11.02	9.13	12.75	3.43	55.94	83.91		1.68
E	1	Propagated under Gas-filled lamps: soil not heated	9.23	8.83	9.40	7.17	10.56	5.10	50.29	75.44		1.51
	2	Propagated under Gas-filled lamps: soil heated	10.01	12.30	12.15	8.61	11.20	5.40	59.67	89.51		1.79
	3	" " " "	11.10	12.65	11.94	10.74	13.77	5.75	65.95	98.93		1.98

Table 7 *(continued).*

House	Plot No.	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre		Total Flats per Acre
			March	April	May	June	July	Aug.	Total			
	4	Propagated under Gas-filled lamps: soil not heated	9.85	9.66	9.14	7.14	10.53	2.56	48.88	73.32		1.46
	5	,, ,, ,, ,,	10.65	9.00	8.86	7.14	8.47	2.10	46.22	69.33		1.39
	6	Propagated under Gas-filled lamps: soil heated	10.95	11.35	11.71	10.12	12.31	5.40	61.84	92.76		1.86
F	1	Propagated under Neon lamps (b): soil heated	10.20	11.47	11.26	10.94	12.33	6.26	62.46	93.69	99.79	1.87
	2	Propagated under Neon lamps (a): soil heated	11.11	12.36	11.94	10.12	11.63	5.91	63.07	94.66		1.89
	3	Propagated under Gas-filled lamps: soil heated	11.70	13.52	13.70	14.00	13.60	7.50	74.02	111.03		2.22
	4	Propagated under Gas-filled lamps: soil not heated	11.61	10.30	9.41	8.66	10.45	4.63	55.06	82.59	79.04	1.65
	5	Propagated under Neon lamps (a): soil not heated	10.37	9.53	8.35	7.73	10.61	3.56	50.15	75.23		1.50
	6	Propagated under Neon lamps (b): soil not heated	9.52	9.00	8.63	9 17	12.33	4.22	52.87	79.31		1.59

may have been partly due to the fact that owing to the exceptionally hot weather, the natural temperature of the beds was five degrees higher than usual, and that the increase in temperature due to heating may not have been sufficient to affect the crop. Also 1934 was a good cucumber season. The weather conditions were favourable to root development and a healthy condition of the plants, and therefore a warm soil which invariably assists root production may not have been necessary. Further, for the first time on a large scale, the heated beds were kept at a constant temperature throughout the twenty-four hours by thermostatic control. In previous experiments the beds were heated at night only and were allowed to cool during the day. This may have affected the results.

During 1935 it was hoped to arrange the experiments so that some beds could be maintained at a constant high temperature while others were heated during the night only. Unfortunately money was not available to purchase the additional equipment required and the project was abandoned.

The previous experiment of maintaining a constant bed temperature of 88—90°F. was repeated, and the results (see Table 7) shewed a crop increase of 27·4% in favour of soil heating.

This result confirms those obtained previous to 1934 and suggests that the exceptional results of 1934 were due to the exceptionally warm sunny weather which favoured the cucumber crop to such an extent that soil warming was unnecessary.

(b) The use of electric light in the propagating houses.

Experiments in this connection have been continued on a larger scale than previously. Young cucumber plants were submitted to five hours' additional light at the end of the natural day, starting with the sowing of the seed and finishing when the plants left the propagating house.

Three sources of light were used as follows:—

(1) 500 watt gas-filled electric bulbs mounted in Benjamin parabolic reflectors.

(2) Neon discharge tubes kindly supplied both by Messrs. Phillips Industrial, Limited, and The General Electric Company respectively.

The results were promising, although it must be noted that the natural light conditions which prevailed during the period of the experiment were so bad that the beneficial effects of the electric light supplied may be a little exaggerated.

The irradiated plants soon shewed the benefit of the additional light, for almost from the commencement of the experiment they grew faster and were more robust than the controls. When the irradiated plants were ready for planting out in the beds they were approximately twice the size of the controls. There was little difference between the plants under the different neon tubes, but they were of better form and were slightly more robust than those submitted to light from the 500 watt electric bulbs, which were a little drawn.

All plants were planted out in their respective beds on the same day, and made rapid growth. It was surprising to observe that seven days after planting the advantage held by the plants treated with neon light had completely disappeared, for no difference could be seen between them and those treated with light from the 500 watt lamps. The irradiated plants, however, were a good deal in advance of the controls.

Picking began from the irradiated plants ten days sooner than from the controls, and this ten day period of high prices was the only advantage resulting from the application of additional light, for as can be seen in Table 7 the total yields at the end of the season were as great from the control plants as the others.

(c) Hybridization.

The task of improving existing varieties, which began in 1934, was continued. The F.1 and F.2 generations of a cross between Butcher's Disease Resister and Delicacy were grown and selections made. So far the progeny have yielded smoother fruits than those of Butcher's Disease Resister, but the neck is much shorter and the flavour greatly improved.

3. Lettuce.

The cultivation of Cheshunt Early Giant lettuce in the glasshouses of the Experimental Station has been continued in an attempt to produce good lettuce for market from October to March. Plantings were made at different dates, the results being shewn in Table 8.

The best lettuce was cut at the end of October and early November from plants set out during the middle of September and during February and March from plantings made early in December.

Good lettuce was cut for the Christmas market, but under the conditions of poor light which prevail at Cheshunt the plants must be set out not later than October 3rd.

Table 8.

Glasshouse lettuce: Cheshunt Early Giant

Date of Planting	Temperature of Houses	Date Cutting Commenced	Date Cutting Finished	Average Gross Price per Dozen Heads
9/10/34	50—52° F.	18/12/34	10/1/35	2.25/–
18/10/34	50—52° F.	11/1/35	4/2/35	3.20/–
4/12/34	50—52° F.	18/2/35	8/3/35	2.90/–
28/8/35	Unheated.	27/9/35	11/10/35	2.26/–
16/9/35	50—55° F.	28/10/35	15/11/35	3.4/–
11/10/35	50—52° F.	18/12/35	17/1/36	2.6/–

The most difficult crop seems to be that planted towards the end of October for cutting in January, but in more favoured districts even this should offer no difficulty. The crop planted during the last week in August produced good heads in four weeks, but fortunately the weather was not too hot. Cheshunt Early Giant lettuce is essentially a short day type and plantings made sooner than the second week in September may bolt, especially in the warmer sunnier parts of the country.

These trials have shewn the usefulness of this variety for autumn and winter work and growers would be wise to give it a trial.

Attempts to obtain sufficient seeds to meet the demand were fairly successful, and some 25 pounds were distributed to growers all over the country during the autumn of 1935. This was grown in California through the kindness of Mr. F. G. Cuthbertson, of the Ferry-Morse Seed Co., San Francisco. It is anticipated that a good stock of seeds will be available in time for next season's work.

In the meantime the Director would be pleased if growers who have tested this variety would tell him what results they have obtained.

4. Cold Frames.

The experiments in cold frames have been continued chiefly in regard to improving the physical condition of the soil, which, as previous experiments indicated, is so important. The frames were planted between February 6th and February 19th, and cutting commenced on April 12th.

The trials included the application of (*a*) sphagnum peat, (*b*) "bacterised" peat, and (*c*) spent mushroom manure. The peat and spent mushroom manure were well mixed with the top 12 inches of soil at the rate of 7 lbs. per square yard, while the dressing of bacterised peat was used at the rate of 7 lbs. per square yard.

Both the peat and spent mushroom manure improved the physical state of the soil, and the lettuce in these frames grew more rapidly and produced larger and better heads than in the control frames where the natural soil occurred. The lettuce in the bacterised peat plots became very large. Hearting was delayed about ten days, but the heads were larger than in the other two treatments.

The experiments proved the importance of the physical state of the soil in lettuce work, and demonstrated the feeding value of bacterised peat. The latter should be tested by market gardeners because it is obvious that the best rate of application must vary in different soils.

A number of different varieties were tested in the natural soil, to which spent mushroom manure only had been added.

Of these the best proved to be Cheshunt Early Ball, a new frame type raised at the Station. The second was Green Frame, with Gotte à forcer and Couches à graine noire only slightly behind. Blackpool proved to be slow in hearting, while Golden Ball lacked uniformity and proved very susceptible to attack by *Botrytis*.

The soil heating experiments were continued, and the results indicated that soil temperatures above 65°F. are too high for spring lettuce in frames because while the growth rate of the leaves was increased, the hearts shewed a tendency to open and bolt.

2. Mycological Investigations.

Diseases brought to the Station and not previously reported are listed below:—

Host.	Disease.	Cause.
Cheiranthus allioni ...	Root rot	*Fusarium sp.*
Chrysanthemum ...	Damping-off of cuttings	*Rhizoctonia solani.*
Chrysanthemum ...	Sclerotium disease.	*Sclerotinia sclerotiorum.*
Cucumber	Stem and fruit rot...	*Botrytis cinerea.*
Fig	Mosaic	*Virus.*
Gladiolus	Dry rot	*Sclerotium gladioli.*
Lilium longiflorum ...	Foot rot	*Phytophthora parasitica*
Narcissus	Leaf spot	*Phyllosticta narcissi.*
Paeony	Ring spot	*Virus.*
Petunia	Foot rot	*Phytophthora cryptogea*
Phlox	Leaf spot	*Septoria phlogis* and *Phyllosticta phlogis.*
Pittosporum	Coral spot	*Nectria cinnibarina.*
Pteris spp.	Leaf eelworm ...	*Aphelenchoides olesistus*
Red Currant	Silver leaf	*Stereum purpureum.*
Tomato	Fruit rot	*Phoma destructiva.*
Tomato	Bushy stunt ...	*Virus.*
Tomato	"Fern leaf" ...	*Virus, Tobacco Virus 1 type.*
Tulip	Grey bulb rot ...	*Sclerotium tuliparum.*
Violet	Rust	*Puccinia violæ.*
Wallflower	Grey mould... ...	*Botrytis cinerea.*
Wallflower	Downy mildew ...	*Peronospora parasitica.*
Wallflower	Mosaic	*Virus.*
Watercress	Mosaic	*Virus, Cucumber Virus 1 type.*
Watercress	Mosaic	*Virus.*

1. Rose Diseases.

P. H. Williams.

In continuing the Rose investigations during 1935, most attention was paid to the study of rose rust.

An attempt was made to ascertain the host range of the different strains isolated and also to determine the conditions necessary for infection.

Host range.

The following strains of rust, *Phragmidium sp.*, were used in the tests :—

Phragmidium A. From leaves of *R. canina* growing at the Experimental Station.

Phragmidium B. From leaves of *R. laxa* received from Mr. Courtney Page in 1934.

Phragmidium C. From leaves of cultivated rose in August, 1934.

Phragmidium D. From leaves of *R. rugosa* in October, 1935.

Phragmidium E. From stems of *R. canina* at Cheshunt, 1935.

Phragmidium F. From leaves of *R. laxa* in August, 1935.

Phragmidium G. From leaves of cultivated rose in June, 1935.

Phragmidium H. From infected buds and stems of Kokulinsky's *canina* in 1935.

Phragmidium K. From infected buds and stems of Deegen's *canina* collected during 1935.

The results obtained with strains A. to D., which were reported in the Twentieth Annual Report, 1934, were confirmed, and in consequence it was decided to extend the trials by including a greater number of different types of *R. canina* and different strains of *Phragmidium.*

The following hosts were employed :—

(*a*) Deegen's *canina.*

(*b*) Kokulinsky's *canina.*

(*c*) Schmidt's Special.

(*d*) *Canina D.* (unnamed).

(*e*) *R. laxa.*

(*f*) Rose Margaret McGredy on seedling briar.

(*g*) Ditto on *R. laxa.*

The nine strains of *Phragmidium* were tested for their power to infect all of the above hosts. This was done by placing uredo-spores on the leaf surface by means of a fine needle and then transferring the plants to a moist chamber where a high humidity was maintained until the morning of the fourth day. Other methods of inoculation were tried but the above was ultimately adopted as general practice. On the fourth day the plants were removed and placed in cool glasshouses, taking care to separate the plants to prevent cross inoculation. The experiments were repeated several times.

As a result of these investigations the strains of *Phragmidium* tested may be classified into four groups.

The macroscopic appearance of the strains was similar when sporulating on a suitable host, with the possible exception of strain E. which at times seemed paler than the rest, but this may be due to paucity of spore production. The sori were between 0·5 and 1·0 mm. in diameter. They were bright yellow in colour and usually caused a yellowing of the upper surface of the leaf immediately above them.

The groups are as follows:—

(1) Strains A. and E. Both strains infected *R. laxa*, Deegen's *canina*, and *Canina D.*

Strain E. also infected Schmidt's Special. They did not infect the cultivated rose.

(2) Strains B., H., and K. These strains infected all the host plants except the cultivated rose.

On Schmidt's Special the sori were often very small and at times there was evidence of infection of the cultivated rose without spore production.

(3) Strain F. This strain differed from Strain B. and the other briar strains. It infected the cultivated rose but neither Kokulinsky's *canina* nor Schmidt's Special, while on Deegen's *canina* and *Canina D.* infection was slight. *R. laxa* inoculated at the same time was heavily infected.

(4) Strains C. and G. These readily infect the cultivated rose, but of the remaining hosts none have been infected except Schmidt's Special. In this case infection was transferred back again to the rose from the briar.

It seems safe to assume, in view of the above results, that one strain at least from *R. laxa* and one strain from *R. rugosa* (see 1934 results) are capable of infecting the rose. On the other hand strains from *R. canina* and its various types cannot be transferred to it.

The strains taken from the rose are capable of infecting certain briars, and infection can be taken from these briars to other roses. The above results are interesting because they appear to confirm the conclusions reached by Mr. Courtney Page, in that the strains from *R. laxa* readily infect the rose, whereas those from *R. canina* do not.

The question whether these groups represent distinct species of *Phragmidium* depends upon certain morphological characters, such as spore size, etc. A great number of uredospores have been measured but conclusive evidence of any

difference in size has not been obtained. This may be due to the fact that the spores swell in water and it is not easy to prepare a suitable medium in which they will not change in form during examination. Measurements of teleutospores, however, have given interesting results.

It was found that in the case of strains from rose six celled spores are most abundant, while seven or eight celled spores are commonest in those from the briars. When comparing strains it is necessary to compare the lengths of spores containing the same number of cells.

In the following Table the results of 100 measurements of each strain are analysed to shew the length of spore in each cell-class. The figures in parenthesis shew the actual number measured in each class. The spore width varies from 15 to 29μ and is approximately the same in all strains.

Average Length of Teleutospores.
(Thousandths of a Millimetre).

No.of Cells.	A.	B.	C	E.	F.	G.	H.	K.
3	—	—	—	—	—	57.8(1)	—	—
4	—	57.8(2)	60.0(1)	—	—	61.7(8)	—	—
5	62.9(3)	69.1(8)	69.7(19)	64.4(1)	—	70.9(30)	64.4(3)	63.2(7)
6	73.4(19)	75.3(22)	83 9(48)	73.1(12)	74.4(2)	84 0(49)	73.6(23)	71.0(19)
7	82.9(51)	83.4(46)	96.3(32)	81.5(53)	83.8(25)	95.4(12)	82.6(51)	81.8(48)
8	95.6(26)	92.5(20)	—	89.7(34)	92.7(41)	—	95.4(21)	92.1(23)
9	111.1(1)	104.4(3)	—	—	100.8(30)	—	103.3(2)	101.5(3)
10	—	—	—	—	111.1(2)	—	—	—

From these figures it appears that the rose strains C. and G. are similar both in the proportion of the different celled spores and in the average lengths of each group of spores. Strain F. also stands out on account of the large proportion of spores containing seven, eight, and nine cells. The remainder shew a predominance of seven celled spores, and with one or two exceptions the average length of each class of spore is very close in all strains. To test these results further the measurements of seven celled spores were tested statistically. Strain G. was omitted owing to the lack of a sufficient number of measurements. These tests shewed that the rose strain was significantly different from the briar

strains, while the latter were not significantly different from one another. The larger size of the spores of the rose strains may be due to the host, and until all the strains can be grown on the same host and their spores measured on that host it would not be safe to differentiate them into separate species.

Overwintering.

(*a*) Teleutospores.

During 1934 all attempts to germinate teleutospores had failed, and this was ascribed to unsuitable methods of storing the infected leaves. In October, 1934, a fresh supply of teleutospores on Rose leaves was obtained through the kindness of Mr. Courtney Page. These leaves were divided into three lots and placed in bags of butter muslin. One bag was hung up in the laboratory, one in a glasshouse, and the third out-of-doors under shelter but exposed on one side to the open. Spores were removed and put to germinate each month. On May 10th, 1935, germination was observed after two days for the first time. Tests were then made at weekly intervals until the end of May and fortnightly during June. Germination was only observed during May and then only in spores which had been stored outside. Only a small proportion of spores germinated. No germination was observed in the case of spores stored under the other conditions and at any other times of the year. It appears, therefore, that the teleutospores must be exposed to winter conditions before they are capable of germinating, and it is possible that a higher percentage germination would occur where spores remain on the leaves under natural conditions where the degree of coldness and wetness is more severe than in the above experiment.

Attempts to infect plants during May from spores stored outside were unsuccessful, although spores taken from the same leaves germinated.

(*b*) Perennial Mycelium.

The most important source of summer infection appears to be the perennial mycelium occurring in the stems and buds. A good deal of this has been found on *R. canina* on the Station Nursery, and on small pot plants of Kokulinsky's and Deegen's *canina*. The infected branches of these small plants appear to die back and it remains to be seen during the coming spring whether the mycelium has penetrated into the other parts of the plant. It is hoped to clear up this point during next season.

The effect of moisture on infection.

It has been found once more that inoculated plants must usually be put into a moist chamber to assist infection, and an attempt has been made to determine the minimum time necessary for exposure to such high humidities. Spores of strain H. were used for inoculating plants of *R. laxa* in pots, which were then placed in the moist chamber for varying periods. During the course of several experiments, the range of exposure covered periods from two to eighty-six hours. Although the resulting intensity of the infection varied from slight to abundant this appeared to be due to the virulence of the spores used as the inoculum and not to the time of exposure. In other words, periods of exposure beyond the necessary minimum did not increase the intensity of infection.

Although in one case infection occurred when the time of exposure to moist conditions was only four hours, this was an isolated case, and in all others infection was not obtained from exposures less than thirteen hours.

The plants in the moist chamber, where the average humidity was approximately 95%, were covered with "dew" each morning and it is suggested that the susceptibility of plants in different districts depends to some extent upon the length of time that "dew" occurs on the plants.

2. Diseases of Early Vegetables.

H. L. White.

(a) "Damping off" of lettuce.

During the early part of the year much trouble was experienced by growers in different parts of the country through "damping off" of lettuce in glasshouses. Patches of thirty or forty plants were affected and examination revealed the dying back of lateral rootlets. In an attempt to find a pathogenic organism responsible for the trouble isolations were made onto different media from plants from four different nurseries. Among the organisms obtained were two unidentified fungi which are pathogenic to lettuce roots. Further work failed to substantiate the possibility that these fungi are primarily responsible for the damage.

Failure to obtain consistent isolations of any pathogenic organism suggests that the affected patches may primarily be due to some other factor. Coldness of the soil, which on a previous occasion has been associated with attacks of "damping off" caused by *Pythium*, may be involved.

(b) "Crown rot" of rhubarb.

The progress of this disease, noted as prevalent in 1934 on a 12 acre field, was followed in 1935 and revealed several points of interest. Examination of stunted plants, with young leaves pale in colour and in advanced stages showing marginal yellowing and wilt, revealed coffee coloured areas of decay extending into the crown, which in some instances was reduced to a spongy chocolate-coloured mass. Isolations on rhubarb agar yielded translucent flesh-coloured bacterial colonies with auriculate margins. These colonies appear to correspond with *Bacillus rhaponticum* (Millard).

No relationship could be traced between the incidence of the disease and different treatments in a fertiliser experiment instituted by the grower. The distribution of diseased plants followed the lines of planting and it was found that the sets used had been derived from two sources, namely, (*a*) three and four year old plants replanted without storage, and (*b*) older plants stored for varying intervals before replanting. A sharp line of demarcation in the field emphasized the superiority, as regards freedom from disease, of the sets replanted without storage. Moreover, losses from the disease in the stored sets became accentuated across the field in the direction of planting so that the sets planted earlier and therefore stored for a shorter time were less affected.

These observations emphasize the desirability of replanting rhubarb sets as soon as possible after lifting and not leaving them exposed to frost and other possible sources of damage, which tend to increase susceptibility to disease.

3. A Survey of Carnation "Stem rot" Diseases, 1925-35.

H. L. White.

Since the publication of the last Report the results of a comprehensive investigation by Dr. G. M. Wickens have become available (Ann. App. Biol. XXII., 630-683). Wickens finds that there are three separate diseases on nurseries which he calls *Verticillium* "wilt" caused by *Verticillium cinerescens*, *Fusarium* "wilt" caused by *Fusarium dianthi*, and *Fusarium* "stem rot" caused mainly by *Fusarium culmorum*. Either of these diseases may be present alone or in combination with one or both of the other diseases. Whereas all three fungi are capable, under conditions similar to those on carnation nurseries, of causing total destruction of cuttings and young rooted plants in small pots, there is some doubt about the ability of either of the *Fusaria* to attack successfully older established plants in beds.

In addition to these diseases a number of others, with superficially similar symptoms, but caused by different fungi, have been noted during the period under review. An extensive survey is necessary to establish the relative importance of carnation "stem rot" diseases.

Alternaria sp.

This disease, investigated by Corbett, is characterized by stunting and wilt associated with vascular infection and browning of the pith. Infection is followed rapidly by death of the plant and it is fortunate that the disease has not been recorded in recent years.

Botrytis sp.

During prolonged periods of damp weather in the winter *Botrytis*, after growing actively on the surface of woody stem-bases, enters the living tissues within and causes wilt of all shoots above the point of invasion. The incidence of the disease is accentuated by masses of *Botrytis* spores dispersed from rotting blooms, for frequently a high percentage of flower-buds become infected by *Botrytis* during wet weather. Since the growth of *Botrytis* on carnation plants seems to remain saprophytic except under very humid conditions the disease does not normally become serious and could probably be eliminated by increase of the temperature.

Fusarium spp.

These diseases fall into two groups.

(*A*) Species which are capable of a semi-parasitic existence on plant remains and consequently have a wide distribution, their spores being commonly encountered in the atmosphere or in water. Such species seem capable of infecting the plants only through a wound and normally cause indiscriminate rotting of the tissues around the point of infection. Among them are *F. scirpi var. acuminatum*, *F. herbarum*, *F. moniliforme var. anthophilum*, etc.

Certain Fusaria enter the plant through aerial infection of a cut "snag" or broken stem or more rarely at the base of a leaf, presumably following germination of the spore in stagnant moisture held by the leaf. Such species are of weak pathogenicity and cause only a limited form of "dieback," though there is evidence that *F. herbarum* is also responsible for loss through rotting of immature buds.

Other Fusaria enter the plant from the soil, and a species believed to be *F. scirpi var. acuminatum* appears to be the commonest. It has been isolated in a high percentage of

cases from the roots of plants attacked by *Verticillium*. Infection of plants weakened by previous fungal attack is presumably secondary and cannot be considered as a separate disease. In other cases circumstances point to this species being pathogenic. For example, two hundred young wilted plants were taken from a bed on a nursery visited in 1935 and a Fusarium, compared with and provisionally identified as this species, was isolated in a high percentage of cases, whereas other fungi suspected of pathogenicity could not be detected. Inoculations with strains that appear morphologically similar to this species give variable results ranging from a slight degree of local rotting to rapid wilt.

Lesions caused by *F. culmorum* are of common occurrence in carnation plants. A high percentage of roots (70%) of plants infected by *Verticillium cinerescens* may contain this fungus. Infection is presumably secondary following the lesions of primary infection by *Verticillium*. In a plant artificially inoculated with this fungus through sterilized soil (probably via a broken root) vascular lesions extending practically to the growing point were obtained, from which *F. culmorum* was re-isolated at intervals apparently free from other organisms. Aerial infection of cut "snags" by *F. culmorum* on nurseries is usually followed by s ight dieback, but in experiments with artificial inoculation at high temperatures the fungus has grown back to soil level and the entire plant has been killed. Such observations lead to the view that *F. culmorum* can behave as a highly active pathogen though it does not seem to attack well-established uninjured plants on nurseries.

Spores of *F. culmorum* are of common occurrence in water and two types of disease of frequent occurrence on nurseries may well be due to an infected water supply. (1) A foot rot of unrooted cuttings in which infection spreads rapidly at high temperature through mois: sand, (2) slow wilt, limb by limb, of established plants lasting for months before final recovery or death of the plant. Infection occurs at the juncture of the main limbs where water normally collects after spraying, the lesions extending very slowly under the relatively cool conditions prevailing on nurseries.

Lesions due to *F. culmorum* are common in the pith and cortex of carnation plants and in the wood for distances of a few inches, but in general *F. culmorum* does not cause a true vascular wilt.

(*B*) Species of active pathogenicity causing a true vascular wilt, namely, *F. dianthi*

This disease appears superficially similar to that due to *Verticillium*, but the vascular tissues have a shredded silvery appearance and are eaten away so that the stems of wilting plants are shrunk and hollow to the touch. Transmission of the disease in the cuttings has not been proved but it is probable. The disease is serious, but has only been noted by the writer on a single nursery from which plants were sent by the grower in 1935. (But the disease has been encountered more frequently by Dr. Wickens).

RHIZOCTONIA SP.

This disease is a collar rot of rare occurrence but it may cause serious losses. The incidence of the disease is believed to be associated with the presence of a moist heavy soil.

SCLEROTINIA SP.

This fungus is responsible for a collar rot which causes the whole plant to wilt. Overdeep planting is believed to have been an accessory factor in inducing the disease on the only occasion it has been recorded.

VERTICILLIUM CINERESCENS.

This appears to be the most important disease of carnations in this country at the present time. An important aspect of the disease is transmission in the cuttings used for propagation. The disease is considered elsewhere in this Report.

4. Verticillium Wilt of the Carnation.

H. L. WHITE.

(a) Transmission of the disease in cuttings.

Proof that the disease may be transmitted in cuttings has been completed by inoculation into carnation plants of fungi isolated from cuttings taken by nurserymen from diseased beds and provisionally identified as *Verticillium cinerescens* (see 1934 Report). Wilt of the inoculated plants followed and *Verticillium cinerescens*, free from other organisms, was re-isolated some distance from the point of inoculation in twenty-four out of thirty plants.

(b) Inoculations with Verticillium.

Six young plants, variety Spectrum, in thirty-two pots were inoculated at soil level with *Verticillium cinerescens* on 31st May, 1935. By 4th July one of the five main limbs of a typical inoculated plant had wilted. By 15th July a second main limb had wilted and by the 24th July the whole plant

had succumbed. Similar observations were made on four other inoculated plants. The remaining plant had three wilted out of six main limbs on the 14th September. The results of the experiment are shewn in Table 1.

Table 1.

Plant Number.	Date of inoculation.	Number of days from innoculation to complete wilt.	Mean daily rate of growth of the fungus (cms.)
1	31/5/35	65	0·58
2	,,	52	0·63
3	,,	106	—
4	,,	45	0·65
5	,,	54	0·59
6	,,	68	0·56

The mean rate of growth of the fungus in the plant was determined by noting with a lens the apparent limit of the lesion in the wood and is a minimal value because the fungus in other experiments has been re-isolated from beyond this point. Re-isolations at this point yielded the fungus in each case. The mean rate of nearly 0·6 cm. per day during June and July in this experiment compares with a mean rate of 0·4 cm. per day during September and October (see 1934 Report). A mean rate of an order of 0·5 cm. per day would correspond with complete wilt of plants in their second year about three months after root infection. This would place the period of maximal infection of commercially grown second-year plants, a type in which the disease is frequently first apparent, in late winter for the period of maximal wilt is in May and June.

(c) Inoculations with Fusarium.

An outstanding feature of isolation work reported in 1934 was the occurrence of a large number of fungi, mainly *Fusaria*, in the cortex and roots of wilting plants. *Verticillium cinerescens* was isolated from the vascular tissues of these plants, shewn to be pathogenic and considered to be the primary cause of the disease.

Inoculations in triplicate with twenty-one cultures, representative of these fungi, have been made. With one exception, apparently a strain of *Fusarium culmorum*, the results were negative, the inoculations causing only a variable degree of local rotting at the point of inoculation. It is concluded that all these fungi were secondary and had invaded the tissues of the plant following primary infection by *Verticillium cinerescens*.

(d) Varietal susceptibility.

Thirty-two plants were inoculated by pricking *Verticillium cinerescens* into the basal joints of a single shoot. The inoculated shoots were all in a corresponding stage of development, and to ensure that this might be the case the plants were selected for uniformity out of a large number. Eight strains of *Verticillium cinerescens* were used and four plants, two of the variety Topsy and two of the variety Spectrum, were inoculated with a single strain. The inoculations were carried out on the 28th May and on the 3rd July the experiment was concluded by cutting out and slitting up the shoots with a sharp knife and noting the furthest point at which a lesion was apparent under a hand lens. This is not necessarily the limit of the distance to which the fungus had travelled but is assumed to represent in different plants equivalent stages of progress.

Table 2.

Relative distances between points of inoculation and apparent limits of lesions cms).

Strain.	Topsy.		Spectrum.	
1	17·6	14·2	17·8	14·5
2	16·3	20·3	14·5	18·2
3	22·5	28·1	11·1	16·8
4	10·5	12·6	16·0	19·5
5	24·7	24·4	12·6	13·7
6	27·0	29·2	15·8	10·7
7	18·7	24·5	18·3	12·2
8	24·7	20·0	11·4	8·3

Table 3.

Analysis of variance of relative pathogenicity of eight strains of *Verticillium* towards two varieties. The method is described in Fishers' Statistical Methods for Research Workers, to which reference may be made. A value of "Z" greater than that in the 5% column denotes a significant difference in variability from that due to duplication of the inoculations.

	σd^2	degrees of freedom.	Variance.	"Z."	5% point.	
Between varieties	338·08	1	338·08	**1·854**	0·752	$n_1 = 1$, $n_2 = 16$
Between strains	115·68	7	16·53	0·345	0·490	$n_1 = 7$, $n_2 = 16$
Interaction between strains and varieties	377·22	7	53·89	**0·935**	0·490	$n_1 = 7$, $n_2 = 16$
Remainder (duplicate variation)	132·5	16	8·3	—	—	—

The results are shewn in Table 2, which suggests that four of the strains have been more virulent towards the variety Topsy, three shew no appreciable difference, and the remaining strain (No. 4) shews preference for the variety Spectrum. It is not easy to reach any definite conclusions without the aid of a method of statistical analysis (analysis of variance) which compares the degree of variability due to duplication of the inoculations with degrees of variability due to strain, variety and the interaction between strain and variety. The results are shewn in Table 3, from which the following conclusions are derived.

(1) In this experiment the variety Topsy has been more susceptible than the variety Spectrum. This was confirmed in the appearance of the plants, for at the termination of the experiment thirteen plants of Topsy were in varying stages of wilting from the basal leaves upwards whereas the corresponding number of Spectrum plants was six.

(2) There is no evidence of the occurrence of degrees of virulence between strains, which affect *both* varieties.

(3) There is definite evidence of differential susceptibility of varieties towards strains. Thus Topsy is the more susceptible variety to strains 3, 5, 6, and 8, but Spectrum is the more susceptible variety to strain 4.

(e) Verticillium "die-back."

On the 19th August it was noted that one of the Topsy plants from the experiment on varietal susceptibility had wilted. Dissection suggested that infection had spread downwards from the inoculated shoot and *Verticillium* was re-isolated at several points, but not from at or below soil level, where the tissues were clean, shewing that the disease was of a "die-back" type rather than a vascular wilt. The normal absence of sporulation on the surface of wilting plants suggests that *Verticillium* "die-back" is unlikely to be encountered on nurseries.

(f) Relation between incidence of the disease and drainage.

Attention was directed by a nurseryman to a block of houses containing patches of diseased plants, extending across 6 beds regardless of intervening paths, while the spread of the patches along the beds was not extensive. In order to ascertain if this sequence was fortuitous a plan was made of these beds, each containing 283 rows, which were automatically divided into 28 areas of 10 rows each by plotting on graph paper. The occurrence of not less than 6 or more than 14 consecutive diseased rows was arbitrarily considered to represent a single diseased patch.

The whole of the 6 beds consisted of 168 areas, which contained 44 diseased patches. The odds against an area and diseased patch coinciding are thus $\frac{44}{168} = \frac{1}{3.8}$. The odds against the coincidence of 6 diseased patches occurring on a single sequence of 6 contiguous areas are $\frac{1}{3.8^6} = \frac{1}{2930}$. But in the whole of the 6 beds there are 28 such sequences. The odds against occurrence by chance of such a sequence of diseased patches throughout the block is thus $\frac{28}{2930} = \frac{1}{105}$. These odds are greater than those conventionally considered to occur by chance and led to search being made for the cause of the distribution of the disease in this way.

On representation to the grower the paths were dug into, disclosing the occurrence of a drain underlying the sequence of diseased patches. There are several possible modes of effect of a drain on the incidence of disease and further observations are being made.

(g) Cross isolations.

Isolations of aster and chrysanthemum with *Verticillium cinerescens* have given negative results, although the aster has previously been reported to be an alternative host. The specific pathogenicity of *Verticillium cinerescens* is fortunate as it will enable tomatoes, chrysanthemums, and probably many other plants to be grown as alternative crops in badly diseased carnation houses.

(h) Measures of control.

These are being revised and will be published as a circular which will be distributed to members.

5. A Disease of Cultivated Heaths.

E. Oyler and W. F. Bewley.

Introduction.

The investigation of the wilt disease of heaths, *Erica hyemalis*, *E. nivalis*, and *E. Willmoreana*, described in the Twentieth Annual Report, has been completed.

An outbreak of the disease occurred on a nursery near London during July, 1934. At that time most of the plants in size 32 pots were standing on the soil; others were on an ash base; while a limited number were plunged in peat. Water was taken from a line of tanks which were immediately suspected of being connected with the disease.

Symptoms of the disease.

The first sign of disease appeared as a greying of the foliage followed by wilting of one or more branches. The wilted condition spread until the whole plant became brown

and dry. Examination of the roots shewed a brown condition of the woody tissue which extended into all the wilted branches. At times the entire root was not involved, and only one side of the plant was affected.

Isolations were made on potato and Quaker Oat Agar and two fungi were isolated, one a species of *Diplocladium* the other a species of *Phytophthora*.

Inoculation experiments.

Attempts to cause wilt by means of the *Diplocladium* sp. proved unsuccessful except in one case during very hot weather, when the inoculated branch wilted after six days. No further attention was given to this fungus.

The culture of *Phytophthora* caused wilting of inoculated branches of *E. hyemalis* within six days. The fungus was re-isolated, proved to be identical with the original culture, and successfully tested for pathogenicity. The fungus was kindly identified by Mr. S. F. Ashby, of the Imperial Mycological Institute, as *P. Cinnamomi*, Rands.

Infection of plants of *E. hyemalis* was obtained by inoculating lateral branches, the main stem at soil-level, the soil of pots containing healthy plants, and by standing pots containing healthy plants on sterilized ashes infected with a pure culture of the fungus.

Plants of *E. hyemalis* were inoculated in one lateral branch and placed in different situations to determine how the disease is affected by temperature. The results shewed that wilting appeared quicker and made more rapid progress at temperatures above 63°F., although the plants took longer to die under cucumber house conditions than in a cooler chamber.

Plants of *E. hyemalis* were inoculated with strains of *P. cryptogea*, *P. parasitica*, and *P. Syringæ*. *P. cryptogea* and *P. parasitica* caused wilting of the inoculated branches in half of the tests. The wilt did not spread beyond these branches. No infection was obtained with *P. Syringæ*.

Lateral branches of plants of *E. hyemalis*, *E. gracilis*, *E. nivalis*, and *E. Willmoreana* were inoculated with *P. Cinnamomi*. Wilting occurred within six days in *E. hyemalis*, and spread rapidly through the plants. In *E. nivalis* wilting occurred in seven days, and in *E. Willmoreana* in four days, but the fungus remained in the inoculated branches and did not kill the plants. In the case of *E. gracilis* the inoculations failed. These results suggest that *E. gracilis* is resistant to this disease, and so confirm the experience of growers.

The heath fungus was shewn to be capable of infecting antirrhinum, beech seedlings, calceolaria, and schizanthus, of causing gall formation at the point of inoculation in *Nicotiana glutinosa* stems, and of rotting apple and tomato fruits. *P. Cinnamomi* was first described in 1922 as the cause of bark canker of cinnamon trees in Sumatra. Since then it has been found causing a disease of pineapple in America and Australia, avocado, *Erica sp.*, *Pinus resinosa* seedlings, and rhododendron in America, walnut in Australia, and sweet chestnut in England.

Conditions governing sporangium production and zoospore liberation.

Experiments were performed to discover if the peat, sand, loam and water used in nursery practice are particularly favourable to the occurrence and distribution of infection.

In these experiments the materials to be tested were placed in test-tubes and half of the tubes in each series were sterilized. Mycelium of *P. Cinnamomi* from young active cultures on Quaker Oat Agar or carrot broth was introduced into the tubes, which were kept at 20°C. The cultures were examined at the end of eighteen hours and subsequently for zoosporangia.

No zoosporangia were produced on mycelium in either distilled or tap water, sterilized or unsterilized. The same applied to sterilized rain water, but a few zoosporangia were produced in unsterilized rain water.

No zoosporangia were produced on mycelium in the sterilized tubes containing sand, compost, soil, three different kinds of peat, or in unsterilized tubes containing baked soil, and water. Zoosporangia were produced in the remaining unsterilized tubes, the greater numbers occurring in the tubes containing compost and peats. Similar results were obtained using damp soil, peats, and compost.

Leachings from soil and compost were prepared, using tap water at 100°C. and 17°C. Occasionally a few zoosporangia were produced in the sterilized tubes, but in most cases no zoosporangia occurred. Numerous zoosporangia were produced in the unsterilized tubes, more being formed in compost-leachings than in soil-leachings. Better results were obtained with leachings prepared with boiling water than at 17°C.

No zoosporangia were produced in leachings filtered through Pasteur-Chamberland filters.

In a further experiment, ripe zoosporangia were transferred to hanging drops of non-sterile compost-leachings, and to tap water. Zoospores were liberated freely from sporangia in the leachings, while in tap water the majority of zoospores were not liberated.

As zoosporangia are formed and zoospores liberated in much greater quantity in mixtures prepared with peat and water, and in compost-leachings than with soil and sand, it is obvious that the compost used for cultivation of heaths is a very favourable medium for the growth of *P. Cinnamomi.* Rain water, which is held in high favour by growers is more favourable to the fungus than tap water.

The effect of fungicides and weed killers on P. Cinnamomi.

Active mycelium, ripe zoosporangia, and motile zoospores of the heath fungus were transferred to solutions of Cheshunt Compound, copper sulphate, mercuric chloride, and sodium chlorate in non-sterile compost-leachings. The results are given in Table 1.

These results indicate that Cheshunt Compound and copper sulphate at a concentration of ½ ounce per gallon, and mercuric chloride at a concentration of 1 ounce to 6 gallons prevent sporulation and kill the fungus. Sodium chlorate at a concentration of 8 ounces per gallon prevents sporulation, and at a concentration of 14 ounces per gallon kills the fungus.

Seasonal effect upon zoosporangium production.

During the course of this work experiments on zoosporangium production have been in progress continually for a period of some fifteen months. Zoosporangium production and liberation of zoospores in the same media varies at different times of the year. It is slight from October to March, and then becomes abundant, especially during June, July, and August.

Sources of infection.

PROPAGATING HOUSES. Diseased specimens from boxes of recently rooted cuttings and pots containing young plants were examined. Death proved to be due to mechanical injury incurred during the process of rooting and potting. In no case was infection by *P. Cinnamomi* observed, and it seems reasonable to assume that the disease does not start in the propagating stages.

"Standing-out" ground.

The disease usually appears six to eight weeks after standing the plants outside, either in the open or plunged in pits.

Table 1.

Effect of fungicides and weed-killers on zoosporangium production.

Series	Method	Solution used: oz. per gallon	Result
1	Mycelium incubated in non-sterile compost leachings	Cheshunt Compound: ½, ¼, ⅛	No zoosporangia produced, mycelium killed
		Copper sulphate: ½, ¼, ⅛ ...	,, ,, ,, ,, ,,
		Mercuric chloride: ⅛ ...	,, ,, ,, ,, ,,
		Sodium chlorate: 14... ...	,, ,, ,, ,, ,,
		,, ,, 13,12,11,10,9,8	,, ,, ,, ,, alive on 6th day
		,, ,, 6. 5 ...	Few zoosporangia and many chlamydospores produced
		,, ,, 4, 2, 1, ½ ...	Many ,, ,, few ,, ,,
2	Ripe zoosporangia transferred to non-sterile compost leachings	Cheshunt Compound: ½, ¼, ⅛	No zoospores liberated, sporangium contents disintergrated
		Copper sulphate: ½, ¼, ⅛ ...	,, ,, ,, ,, ,, ,,
		Mercuric chloride: ¼	,, ,, ,, ,, ,, ,,
		Sodium chlorate: 8, 7 ...	,, ,, ,, ,, ,, ,,
		,, ,, 6, 5 ...	No zoospores liberated
		,, ,, 4	Some zoospores liberated, some germination in sporangium
		,, ,, 2, 1, ½ ...	Zoospores liberated
3	Motile zoospores transferred to non sterile compost leachings	Cheshunt Compound: ½, ¼, ⅛	Zoospores rounded off and disintergrated
		Copper sulphate: ½, ¼, ⅛ ...	,, ,, ,, ,, ,,
		Mercuric chloride: ⅛ ...	,, ,, ,, ,, ,,
4	Motile zoospores transferred to non-sterile compost leachings	Sodium chlorate: 8	Movement stopped almost at once Majority of zoospores disintergrated
		,, ,, 7, 6 ...	Movement stopped almost at once. Some zoospores disintergrated, some germinated
		,, ,, 5, 4 ...	Movement stopped almost at once. Zoospores germinated
		,, ,, 2	Movement stopped less rapidly. Zoospores germinated
		,, ,, 1, ½ ...	Zoospores remained motile

Peat used as plunging material was tested and found to contain *P. Cinnamomi.* Afterwards it was discovered that this peat had been taken from a heap made up of contents from old pots used during the previous year.

Although *P. Cinnamomi* was not isolated from the ashes which constituted the "standing-out" ground it was proved that plants become infected when stood upon ashes infected with a pure culture. Thus the possibility of disease starting in this way seems established, and sterilization of the "standing-out" ground after each crop is essential.

In one epidemic of the heath disease, a crop of calceolarias in pots had been stood out just before the heaths, and according to the grower these had suffered severely from a wilt disease. Specimens were not available for examination, but in view of the fact that the calceolaria is another host for *P. Cinnamomi* it is possible that this fungus was the cause of the injury.

Water supply.

The water in the tanks was examined and found to contain the organism in quantity, and therefore constituted another serious source of contamination.

Compost from old plants.

Occasionally "balls" of compost and roots taken from plants which proved unsuitable for marketing have been retained by growers for mulching and other purposes. Samples taken from a heap proved to be infected with the heath fungus, and so a third source of infection has been detected.

Control measures.

These depend not only upon the observance of general rules of hygiene, but also upon eliminating the particular sources of infection to which reference has been made.

In previous tests Cheshunt Compound and copper sulphate at a concentration of $\frac{1}{8}$ ounce per gallon, mercuric chloride at a strength of $\frac{1}{6}$ ounce per gallon, and sodium chlorate at a strength of 14 ounces per gallon readily destroyed cultures of *P. Cinnamomi.*

Of these compounds, copper sulphate is recommended as a method of disinfecting the "standing-out" ground because of its low cost and safety. The solution may be prepared by dissolving 1 ounce of copper sulphate in 8 gallons of water, and the rate of application should be 1 gallon of this solution per square yard.

Infected water tanks may be sterilized by formaldehyde after they have been cleared of débris and scrubbed with water. Formaldehyde solution of the strength referred to above should be added to such a depth that the pipes connecting them are filled. The solution should also be sprayed over the walls and on the surrounding ground. The tanks should be covered with boards and sacks for forty-eight hours, after which the formaldehyde solution may be run off and the tanks well washed with clean water.

It has been shewn that when infected peat is kept in water the fungus sporulates freely and leads to severe infection of the water. Therefore it is important to prevent infected roots with the surrounding compost from being thrown into the tanks. Some form of covering is essential.

Although all attempts to isolate *P. Cinnamomi* from peat purchased for the potting compost have failed, it is important to remember that this fungus can infect beech seedlings and it would be wise to reject any peat from the neighbourhood of beech trees.

It must also be remembered that this fungus can attack Antirrhinum, Calceolaria, and Schizanthus.

Pots, boxes, etc., which have been used previously for the cultivation of heaths or any of the other host plants, should be sterilized by heat or by formaldehyde.

Finally, all roots and "balls" of compost from diseased or rejected plants must either be destroyed by fire, or must be sterilized by heat before storing for future work.

These measures have been tested on a nursery where this disease has caused severe damage and have proved successful, the resulting crop being free from all infection.

6. Virus Diseases.

G. C. Ainsworth.

(a) General.

During 1935 mosaic, yellow mosaic, spotted wilt (which still appears to be relatively rare on large tomato nurseries though widespread in the country), and streak disease of tomato were all recorded, and isolated outbreaks of green-mottle mosaic, yellow mosaic, and yellow-mottle mosaic of cucumber noted.

In one exceptionally severe outbreak of mixed-virus streak of tomato investigated nearly 100% infection had occurred. The plants affected were the first crop in a new block of houses built on land that carried potatoes the previous year, and the source of the potato virus was, presumably, the potato plants, developed from tubers which had remained in the ground, which grew up among the tomatoes. Other houses on the same nursery contained little disease.

Several virus diseases, either undescribed or new records for this Station, were noted during the year.

A mosaic disease of wallflowers was experimented with. The disease was transmissible by juice inoculation from wallflower to wallflower and from wallflower to tobacco (var. White Burley) and *Nicotiana glutinosa*. The virus appeared to be similar to that described by Hoggan and J. Johnson (Phytopathology, xxv., 640-4. 1935) and the disease similar to the one described by K. M. Smith (Gardeners' Chronicle, xcviii., 112 1935, and Ann. appl. Biol., xxii, 239-42, 1935) though local lesions only developed in *N. glutinosa*.

An instance of paeony ring spot, to which attention was drawn by D. E. Green (Gardeners' Chronicle, xcviii, 213, 1935), was examined through the kindness of Dr. M. M. Walker.

The investigations on two new virus diseases of tomato and mosaic diseases of fig and watercress are reported below.

(b) Two new virus diseases of tomato.

(1) "Bushy Stunt" of tomato.

The name "Bushy Stunt" has been given to the first of the two new virus diseases of tomato which have been under investigation because severe stunting and a bushy type of growth are prominent symptoms of this disease on tomato plants of crop size. On seedling plants the symtoms are rather different, and though characteristic and useful for diagnosis are of less interest to growers.

Symptoms on tomato. In the early stages of the disease on both seedling and larger plants growth practically ceases and there is a yellow spotting of the upper leaves. In a crop plant, or a seedling which survives the attack, subsequent growth is slow, the leaves produced are frequently twisted, narrowed, and generally malformed, and, also, often shew scattered yellowish or brown coloured spots. (These spots, and those developed as a first symptom of the disease, are often ring-like). The lower leaves droop, turn yellowish, and may drop off. Little fruit is produced, and though that

developed on experimental plants has been for the most part unmarked, but small in size and a bad shape, an occasional fruit has shown ring-like markings when ripe.

The symptoms on seedling plants are usually more severe than on larger plants and death frequently results. There is the same yellow spotting and severe stunting but the drooping and yellowing of the lower leaves (which may take on a purplish colouration) is more pronounced. Lesions, resembling those of streak disease, occasionally develop in the upper part of the stem and in the stem-ends of the leaf stalks, and these hasten the death of the plant. The stunting, accompanied by poor root development, appears to render plants more susceptible to attack by soil fungi, for a lesion occasionally develops in the collar region, when the plant topples over as when "damping off."

Properties. The virus can be filtered unchanged through Pasteur-Chamberland filters, and Dr. K. M. Smith, who concluded from his ultra filtration studies the approximate particle size of this virus to be 17—25 mμ, kindly subjected a sample of the writer's material to filtration through Gradocol membranes.

The virus is inactivated by exposure in extracted tomato juice to 80°C. for ten minutes and survives a month or less when stored in juice at laboratory temperature. (Thirty-one days is the maximum period that the virus has remained active in the several tests made).

Host range. On *Nicotiana tabacum* (var. White Burley) and *N. glutinosa* necrotic local lesions are produced. No systemic infection has been observed.

Cow Pea (*Vigna sinensis**) is a useful differential host plant for this virus. Small reddish-brown coloured lesions develop on the leaves inoculated and no systemic infection occurs. The other common tomato viruses do not cause symptoms on this host.

Datura Stramonium. Systemic infection occurs and the effect of the disease is very severe on this plant. More or less circular, yellowish coloured local lesions, which sometimes become necrotic, develop on the leaves inoculated and later when these leaves turn yellow there is a very noticeable retention of chlorophyll around the lesions. Systemic symptoms are yellow spotting of the leaves which become variously distorted, and severe stunting of the plant. At times there is some necrosis.

* I am indebted to Dr. K. M. Smith for seed of this plant.

(2) A disease of the "fern leaf" type.

A second disease was the subject of an illustrated note in the Gardeners' Chronicle (vol. xcviii, p. 320-1). It is characterised by severe distortion, of the "fern leaf" type, of tomato leaves, and in addition leafy outgrowths, "enations," may develop from the undersides of the leaves. A mottle, similar to that of ordinary tomato mosaic, may be exhibited, and although the fruit does not appear to be marked it is reduced in quantity and of poor quality.

The virus. The virus has proved to be one of the tobacco mosaic group. It is filterable unchanged through Pasteur-Chamberland filters, has a thermal death point of 90°C., and is resistant to ageing *in vitro*. Immunity studies have shewn it to be incapable of infecting a plant previously inoculated with *tobacco virus 1*, and when combined with *potato virus x* typical mixed—virus streak of tomato results.

The host range as far as tested appears similar to that of *tobacco virus 1* and on tobacco (var. White Burley) gives rise to similar symptoms. On *N. glutinosa* and *Datura Stramonium* no systemic infection has occurred; necrotic lesions on the leaves inoculated being the only symptom. Cucumber plants cannot be infected.

This virus should, it is thought, be considered a strain of *tobacco virus 1*.

Discussion. The first disease described above, "bushy stunt," is quite distinct, as regards symptoms on tomato, from the other tomato virus diseases of this country. It can be transferred from plant to plant by juice inoculation, that is to say it could be spread by pruning operations, but experiments have shewn seedling plants to be much more easily infected than older plants. On one nursery where the disease was first noticed on several isolated plants there appears to have been no subsequent spread. There is probably an insect carrier of this virus as yet unknown, and under favourable conditions it is likely that the disease would spread more rapidly.

The symptoms of the second disease closely resemble the typical "fern leaf" of tomato (caused by *cucumber virus 1*) although the new disease is caused by a virus quite distinct from *cucumber virus 1* and differs in such symptoms as the leaf enations. When fern leaf of tomato was described in the 19th Annual Report (p.p. 58--9) only that caused by a cucumber virus had been recognized in the country. Tomato fern leaf caused by a virus of the tobacco mosaic type, has,

however, recently been described in Russia. The tomato mosaic virus "fern leaf" disease is very infectious and is easily spread by any cultural operation requiring handling the plants. For prevention and control, precautions similar to those against tomato mosaic should be taken.

These two diseases are, at least potentially, serious to tomato growers. They already exist scattered throughout the country, Bushy Stunt in the West of England and Northern Ireland; the Fern Leaf disease in Hertfordshire and S. E. Scotland, though the damage done so far does not appear to have been very great. It is, however, essential that growers should be able to recognise these diseases and co-operate in their eradication. The roguing of affected plants would probably be sufficient to check outbreaks on an epidemic scale in the country.

(c) Fig mosaic.

A fig tree of the variety White Ischia growing in a pot and under glass at this Station was found to be shewing symptoms similar to those of fig mosaic, a virus disease that has been described in California and reported elsewhere.

The fig tree under observation has shewn leaf symptoms of two types. Some leaves exhibited irregular yellowish-green blotches, often with paler coloured margins, and up to half an inch or more across, distributed on the lamina with little relation to the veins, while the leaves have shewn pale green spots or bands usually associated with the larger veins. These latter spots often had narrow reddish-brown margins. The coloured areas were quite superficial and were not seen, or were inconspicuous, when the under surface of the leaf was examined. Many leaves on the tree appeared normal and the distribution of the mottled leaves was rather irregular. An occasional fruit shewed a few spot-like markings resembling those described as symptoms of the disease in California, but the tree was not seriously affected.

Nothing definite is known regarding the method by which the disease is spread in nature but insect agency is probably responsible. In California experiments have shewn that the disease can be spread by grafting and that it reappears in cuttings taken from diseased plants but seedlings raised from seed taken from mosaic affected parents shewed no signs of disease. At Cheshunt a cutting taken from the mosaic affected plant reproduced the disease.

Fig mosaic, though widely distributed, cannot be considered a very serious disease. At present no definite control measures can be recommended, but it would certainly be well

to ensure that stocks are not propagated from any trees shewing the slightest signs of disease, for propagating from mosaic affected trees multiplies the disease which might gradually assume greater importance.

(An illustrated note on fig mosaic (of which the above is an abridged account) appeared in the Journal of the Royal Horticultural Society, Vol. LX., pp. 532—3, 1935).

(d) A mosaic disease of Water Cress

(*Nasturtium officinale*).

Early in 1935 Dr. G. H. Pethybridge sent for examination a specimen of water-cress suspected to be suffering from a virus disease, and later in the year more material of the same disease was received from Mr. J. Rees.

Affected plants shew a distinct yellow mottling of the leaves which are also slightly deformed and such plants are very slightly stunted. Though the disease is transmissible with great difficulty by mechanical inoculation and an attempt to transmit the disease by the use of aphids failed, it can be reproduced indefinitely by taking cuttings from affected plants, (parallel series of cuttings from healthy plants exhibiting no abnormality) and appears to be a virus disease. A similar disease has been recorded in Czecko-Slovakia by Blatný.

During the summer a plant of water-cress, growing in a garden in a bed of cress grown for salad purposes, was found to be attacked by what was thought to be the same disease. There was a similar yellow mottling of the leaves but the stunting of the plant was more severe. From this plant a virus, which proved to be of the *cucumber virus 1* type, was readily isolated. It produced the characteristic symptoms of yellow-mottle mosaic on cucumber and was transmitted to to tobacco (var. White Burley) and *Nicotiana glutinosa* and agreed with *cucumber virus 1* in physical properties. This is an interesting new host record for *cucumber virus 1*.

(e) An instance of recovery from spotted wilt.

In April, 1934, three flowering Hippeastrum plants suffering from spotted wilt were examined. The plants shewed severe yellow spotting and streaking of the leaves and flower stalks and the presence of spotted wilt virus was demonstrated by inoculating tobacco plants. As judged by the number of local lesions produced on tobacco the concentration of virus in the Hippeastrum plants was exceptionally high. The three plants were "potted up" but made no further growth and all the

leaves died down. Then, as is the usual cultural practice with Hippeastrums, the soil was allowed to dry out. In late autumn the bulbs were again watered when each plant produced several healthy leaves. The following spring two of the plants flowered, all three appeared quite healthy, and no virus was detected in them.

Two possible explanations suggest themselves. Either, as the original infection of the plants occurred in 1934, the virus did not invade the bulbs on account of the early dying down of the leaves (though this is thought unlikely as the symptoms appeared on all the aerial parts of the plant), or the drying out of the soil and the cessation of growth of the bulbs during the summer months may have destroyed any virus present in the bulbs. Spotted wilt virus is known to be easily inactivated by short exposure to a temperature of about 40°C. or by a few hours exposure at room temperature in extracted juice (other viruses such as that of tomato mosaic are very much more resitant in these respects) so the second explanation is thought to be not improbable.

(f) Some effects of tobacco mosaic virus on the growth of seedling tomato plants.

An investigation of the effect of *tobacco virus 1* on the growth of seedling tomato plants, carried out in co-operation with I. W. Selman, was completed. A detailed account has been published elsewhere* but the results may be briefly summarised as follows:—

A statistically significant negative correlation was shewn to exist between the growth rate of seedling tomato plants and the length of the incubation period of the disease.

Evidence obtained suggested that the relative effect of the virus on the growth rate of infected plants subsequent to the appearance of symptoms is the same both in summer and winter.

Various effects of the virus on the percentage water content of the plant have been described.

* Ann. Appl. Biol., XXIII. 89—98.

3. Entomological Investigations.

E. R. Speyer.

1. "Thrips" injurious to the Carnation plant.

The Onion Thrips (*Thrips tabaci*, Lind.), a vector of spotted wilt disease of tomato and other plants, pest of considerable importance upon the flowers of cyclamen, arum, and chrysanthemum, and upon the foliage of cucumber, melon, calceolaria, and bean grown under glass, as well as to agricultural crops in both temperate and tropical climates, is the insect primarily responsible for the characteristic fleck markings upon the flowers of carnation in the glasshouses of this country and the continent.

The life-history of *T. tabaci* upon the foliage of the cotton plant, grown under glass, has been investigated in detail by Miss E. I. MacGill (1927), who gives the following summary (p. 511):—

"The life-cycle of *Thrips tabaci* from oviposition to imaginal emergence on cotton plants, under conditions of temperature varying between a mean maximum of 26·7°C. (80°F.) and a mean minimum of 11·25°C. (52°F.) . . . . has a duration of 23 to 31 days, comprising an egg stage of 8 days, two larval stages with a combined duration of 10 to 14 days, a prepupal stage of 1 to 2 days, and a pupal stage of 4 to 7 days . . . . . The length of the life-cycle is decreased by increase of temperature."

It should be added that the eggs, some sixty in number, are inserted singly *beneath* the surface of the leaf, and that when full-fed the larvæ leap from the foliage to the ground, in the surface of which, or in hollow pieces of straw lying thereon, they complete the pupal transformations (see Speyer, 1931). The male sex has been recorded only in certain tropical countries, and by Dr. G. Morison in the North of Scotland (out-of-doors, see Speyer, 1934); under glasshouse conditions in this country reproduction appears to be entirely parthenogenetic, and certainly was so during the present investigation.

Through the kindness of Messrs. Tacon & Horwood, carnation plants of six different varieties became available for a biological study of the insect, and for a preliminary inquiry into possible means for its control during the summer of 1935.

The plants in 9 inch pots upon staging were grown in a single glasshouse, and were of the following varieties, the flower colour being indicated for each :—

Regal ...	... 20 plants.	Fancy—mauve and violet grounds.
Madge ...	... 23 „	Fancy—yellow and orange grounds.
Eileen Low	... 19 „	Pink.
Salmon Spectrum	16 „	Medium salmon pink.
Topsy ...	... 18 „	Crimson.
Robert Allwood...	9 „	Bright Scarlet.

The plants came into bloom in the order named, from the end of May until the beginning of July, and all flowered profusely until well into August.

It was especially noted that, under the conditions of high temperature prevailing during the summer months, the blooms became fully open six to ten days after the points of the calyx first separated from one another, and that this period was not materially altered when opening blooms were enclosed in celophane bags.

Large numbers of *Thrips tabaci* were introduced into the glasshouse at intervals from the end of May until the middle June. The insects were collected from cucumber, melon, and cotton plants, and later from chickweed; during July severely infected bean plants were grown amongst the carnations, so that a constant source of infestation was assured.

A periodic examination of the foliage of the plants and the bracts at the base of the calyx revealed neither the presence of eggs within their tissues nor of larvæ feeding upon them. Feeding marks made by adult insects occurred to a small degree mostly upon older leaves, especially in the case of the variety Robert Allwood. It is shewn later that only the outside of the calyx shortly before, and the petals and occasionally the inside of the calyx after the bloom opens, are chosen for the deposition of the eggs. Further, that marking of the petals is usually due more to feeding by the adults than by the larvæ.

The compact nature of the calyx of unopened flowers rendered entry of the insects into them, with few exceptions, impossible.

The infestation was therefore confined to the calyx and the petals, but by no means all the varieties employed shewed equal susceptibility to or evidence of such infestation.

The flowers of the varieties Madge, Eileen Low, and Spectrum, of which hundreds were examined, appeared to be entirely immune, although they were exposed to infestation equally with the other three varieties.

Blooms of the variety Regal shewed little or no external evidence of attack though they were found to contain large numbers of adults and larvæ throughout the period of observation, in addition to larvæ of *Taeniothrips atratus*, Hal., to the end of June. Adults of the latter insect gained access to the house from outside, an occurrence which made it necessary to determine the identity of all insects collected from the blooms of the remaining two varieties.

Records taken throughout the month of July shewed that 75% of the blooms upon the variety Topsy, and at least 85% of those upon Robert Allwood had petals marked to a greater or less extent by *T. tabaci*. The latter species was the only one found to inhabit the flowers of Topsy, and in the case of Robert Allwood, one flower only of the many examined contained any other. This full bloom, cut on July 10th, was tenanted by an adult male, ten pupæ, and five larvæ of the Rose Thrips (*T. fuscipennis*, Hal.), which was being bred in an adjoining house, in addition to an adult female and six larvæ of *T. tabaci* The larvæ of the Rose Thrips do not leave their food plant when ready to pupate.

The eggs of *T. tabaci*, although large as compared with the size of the insect, are only just visible to the naked eye when laid in the tissues of some white flower, such as Arum: in those of the carnation, whether of the calyx or petals, they could not be detected with any certainty even under considerable magnification. It therefore became necessary, in order to detect their presence, to soak all material to be examined for several weeks in alcohol of not more than 70% strength, a process which rendered it sufficiently transparent for study under a binocular microscope.

The results of a few of these examinations are given in tabular form: the extent of marking upon the petals is indicated in the extreme right hand column, and the number of eggs recorded upon the *outside* of the calyx and in the petals includes both hatched and unhatched eggs.

It is gathered from these examples and other observations that the Onion Thrips may begin to deposit eggs upon the outside of the calyx tube several days before the points of the calyx separate, but that the petals may be preferred for this purpose when the flower is well open as shewn by example (*f*).

The majority of eggs were located in the distal region of the calyx and petals, but they sometimes occurred in the narrow bases of the petals in wide-open blooms. No eggs could be found in the tissues of the stamens or pistils.

Variety Robert Allwood.

Date	Age of bloom*	Amongst Petals		No. of Eggs		No. of Petals		No. of Petals
	Days	Adults	Larvæ	In Calyx	In Petals	With Eggs	Without Eggs	Marked
(*a*) 8/7/35	4	2	30	106	0	0	45	37
(*b*) 10/7/35	3	1	3	19	2	1	46	5

* From the time of separation of the calyx points.

Variety Topsy.

Date	Age of bloom*	Amongst Petals		No. of Eggs		No. of Petals.		No. of Petals
	Days	Adults	Lavæ	In Calyx	In Petals	With Eggs	Without Eggs	Marked
(*c*) 1/7/35	7	1	0	0	0	0	53	32
(*d*) 6/7/35	12	0	26	35	10	3	52	50
(*e*) 6/7/35	10	0	4	5	2	1	46	20
(*f*) 9/7/35	7	2	6	3	124	33	11	44
(*g*) 9/7/35	7	1	0	2	1	1	45	5
(*h*) 9/7/35	7	1	2	9	27	6	45	14
(*i*) 17/7/35	1	1	0	14	1	1	45	9
(*j*) 17/7/35	1	0	1	1	0	0	45	2
(*k*) 17/7/35	2	2	1	2	0	0	45	7

* From the time of separation of the calyx points.

In examples (*d*) and (*e*), the opening flowers had been protected from further invasion by adult insects by means of celophane bags, respectively four and two days before they came into full bloom; the absence of adult insects from them, and from flower bud (*j*), suggests that a single female may

deposit its eggs in more than one flower. It was usual, however, to find one or two adults in flower-buds of which the calyx-points had not long separated, and as many as four in wide-open blooms.

Examples (*a*), (*b*), (*d*), (*e*), (*j*) and (*k*) indicate that the larvæ, on hatching, creep forthwith from the outside of the calyx to such petals, or portions of them, as may be exposed: no larvæ were at any time found amongst the bracts at the bases of the calyx. It is, therefore, probable that many larvæ which hatch from the eggs, prior to separation of the calyx-points, perish. The period of time over which deposition of the eggs takes place in this insect is known to be a long one. Example (*c*) illustrates the amount of injury which may result to the petals from the feeding, presumably, of a single adult up to the time the flower is ready to be cut for the market.

On July 4th, forty-three very young buds were removed as when disbudding from plants of the variety Topsy. Within the hollow interior of two of these, an adult Thrips was found: they had effected entry through the incomplete calyx. No eggs occurred in the tissues of these disbuds. When blooms were allowed to remain upon the plants after they should have been cut, the number of adults amongst the petals increased, while that of the larvæ decreased. This was due to a tendency of the adults to congregate in over-full blooms, and to the habits of the larvæ when they were ready to pupate. Only in two instances was a pupal stage discovered amongst the petals of the flowers.

To determine the fate of the large numbers of larvæ contained in younger blooms, a severely marked flower of the variety Robert Allwood, past the time of full-bloom, was placed over a large dish of water on July 24th. Upon the following morning, already, eleven larvæ had left the flower, and were floating upon the surface of the water. No fewer than forty-eight full-fed larvæ escaped from this flower, the majority at night-time, up to August 2nd. When examined four days later, six adult insects only were present amongst the flower petals. A good number of the larvæ which had emerged from the bloom were kept floating upon water, and in this uncongenial environment, they moulted twice, passing through the prepupal and pupal stages without hindrance; a few even attained maturity.

An interval of two days elapsed between emergence from the flower, and attainment of the prepupal stage. The latter and the subsequent pupal stage occupied each a period of two days on the average, while a further period of six days elapsed before the pupæ became adults. Under natural conditions the larvæ would have pupated in the ground.

Owing to the comparatively short period over which the larvæ can feed in the blooms before the latter are cut, it becomes evident that a good number of the insects are sent to market from commercial nurseries. Any full-fed larvæ within them at the time of transport might pupate in the packing boxes, but it is unlikely that they would survive long in absence of sufficient moisture. With an insect which is so common out-of-doors, it is unlikely that distribution, if indeed possible, in returnable market boxes, is of any consequence.

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2. Experiments in the control of Thrips tabaci.

Experiments were directed towards the possible protection of the blooms from invasion by adult insects, as little hope can be entertained of killing them, or their young, when once established amongst the petals.

(1) Dusting with Pyrethrum.

A certain measure of success from the use of Pyrethrum and mixtures of Pyrethrum and sulphur dust has been reported in the control of a Thrips which injures the flowers of fruit trees in Australia.

Carnation plants of the varieties Topsy, Robert Allwood, Eileen Low, and Spectrum were accordingly treated with Pyrethrum powder, and a mixture of one part of the latter with nine parts flowers of sulphur, blown from a hand bellows duster, at intervals respectively of three, seven, and fourteen days.

The treatment was started on June 7th, so that in the case of the varieties Topsy and Robert Allwood, the dusts were applied for a period of at least 10 days before any of the blooms began to open.

Not only did the dusts render the foliage of the plants unsightly, but that containing sulphur caused severe injury to the blooms during periods of sunshine. When several flowers of the variety Topsy, treated at intervals of three days, had partially opened on June 24th, it was found that the petals of most were already severely marked by Thrips, and that they contained both larvæ and adults of *T. tabaci*.

The treatment was therefore abandoned as unlikely to effect any control.

(2) Application of Naphthalene.

The Onion Thrips is well-known to be susceptible to the vapour of naphthalene.

On July 4th, all blooms of the variety Topsy which shewed any markings of the petals made by Thrips, were removed from twelve plants: six of these were set aside as controls, and the other six treated by sprinkling Grade 16 Naphthalene over their foliage. Both sets of plants were exposed to equal chances of infestation by Thrips.

Full ventilation was given to the houses in which the plants stood, and it was necessary, in order to maintain an odour of naphthalene about the plants, to repeat the treatment daily during hot weather.

In the course of twelve days from the first application, twenty-seven full blooms were cut from each series of plants. From the untreated controls, five blooms shewed no markings, eleven had the petals slightly, and eleven the petals strongly marked; from the treated plants, the figures were respectively fifteen, seven and five. It appeared, therefore, that some effect had been obtained in preventing the adults from visiting the flowers by this treatment, which did not appear to cause any injury to the plants.

It is, however, doubtful if such a method would find practical application upon commercial nurseries.

(3) Naphthalene Fumigation.

During August, Red Spider mite, which had originated upon plants of Robert Allwood, became established upon the other varieties. On August 27th, Mr. Read carried out a naphthalene fumigation by means of a lamp, using 2 lbs. naphthalene to the house, of which the capacity was 3,000 cu. ft. A second fumigation followed upon September 5th, the period being from 4 p.m. to 9 a.m. on each occasion. The fumigation not only successfully rid the plants of the mite, but after it, the few flowers which still came into bloom upon the varieties Topsy and R. Allwood shewed no signs of Thrips attack.

It should be remembered, however, that the foliage of the plants was old at the time, and would not be likely to shew injury from fumigation. Further, owing to the presence of pupæ of *T. tabaci* in the soil, it is unlikely that the house was entirely freed from this insect.

Future Investigations.

Mr. C. Engelmann very kindly provided a fine set of young plants upon which some flowers appeared during the winter months. Flowers of the varieties Othello (crimson) and Gladys (salmon pink) shewed evidence of especial susceptibility to attack by *T. tabaci*, and amongst the petals both adults and larvæ of the insect have been found. As upon Cyclamen and Arum, breeding persists also upon carnations during the winter. When these plants come into full flower, it is intended to carry out a series of experiments with deterrent sprays.

3. Rose Thrips (*Thrips fuscipennis*, Hal.).

Mr. A. Pollard very kindly provided fifty rose plants for investigation into possible control measures for Rose Thrips.

In addition to causing much injury to the blooms of roses grown under glass upon some nurseries, the insect sometimes breeds extensively upon the foliage of cucumber plants. From the latter, Mr. B. Rochford was good enough to send living specimens from Slough, and on May 28th these were distributed amongst the rose plants. They were observed to deposit eggs within the tissues of the young shoots almost at once, but as advanced larvæ were found already upon June 3rd, it was apparent that the plants had already been infected, very probably from overwintering adults contained in the soil round the roots. It was noted that considerable injury was caused to the leaflets during the process of oviposition, and later by feeding of the larvæ, though the most conspicuous damage was that to the opening blooms at a later period.

(1) Dusting with Pyrethrum.

Encouraging reports having been received from Northern Ireland in the control of this pest by applications of Pyrethrum powder. This insecticide and a mixture of it with flowers of sulphur were dusted upon series of plants at intervals respectively of three, seven, and fourteen days, starting on June 6th. Upon hot days, the sulphur mixture caused serious injury to the foliage, and Pyrethrum dust alone was subsequently employed. Towards the end of June, it became necessary to damp the plants over twice daily. A census of flowers injured and uninjured by Thrips was taken on July 8th, when it was found that as many blooms upon treated as upon untreated plants had been damaged by the insect. All the experimental plants, twenty-one in number, were now dusted every three days, and as no appreciable effect upon the Thrips had been produced by July 23rd the experiment was abandoned.

(2) Poison-baits.

A spray containing sugar and Paris green, and acting as a poison-bait, is recommended in the United States for the control of Gladiolus Thrips.

The application of Paris green to rose plants was not considered advisable, and an experiment upon isolated females of *T. fuscipennis* shewed that sodium fluoride in comparatively weak solution was poisonous to this insect.

Sprays containing 1% sodium fluoride solution, and either brown sugar, white sugar, or treacle, were applied to flowers known to contain the insect. From counts of dead insects contained in them, twenty-four hours after application, it was concluded that treacle was unattractive, and white sugar less attractive than brown sugar. During July and August, series of plants were lightly sprayed with solutions of brown sugar and sodium fluoride in varying proportions of 2% to 7% of the the former and ·05% to 1% of the latter: twenty-four hours after application, such open flowers as were available were examined for the insects, dead and alive, which were present amongst the petals. Owing to the very variable number of insects in the blooms, figures in the accompanying table refer only to cases in which from two to four flowers were available:—

	No. of Blooms		Brown Sugar	Sodium Fluoride	Dead			Living			Approx % Females Killed
					Males	Females	Larvæ	Males	Females	Larvæ	
(*a*)	2	Control	7%	0%	—	—	—	5	8	—	—
(*b*)	3		7%	1%	5	15	6	2	10	0	60
(*c*)	3		7%	·5%	9	26	2	6	35	4	40
(*d*)	4		3·5%	1%	1	13	4	3	8	4	60
(*e*)	3		2·5%	·25%	10	17	1	4	20	5	45
(*f*)	4		2·0%	·25%	0	5	2	3	17	6	20
(*g*)	2		2·5%	·125%	8	0	0	11	18	2	0
(*h*)	2		0	1%	7	4	—	13	10	2	30

Pupæ occurred amongst the petals, but are not included as they cannot feed. It is usual to find some dead males in flowers under natural conditions, and being very active many

no doubt visited the flowers shortly before they were cut from the plant: the percentage of males killed is therefore not given, and too few larvæ were present to draw any conclusion further than that some fed upon the baits and in many cases succumbed. With the use of such a poison-bait over a short period of time. the percentage figures for females killed are necessarily erratic.

It appeared that a spray containing 3·5% brown sugar and ·3% sodium fluoride might give satisfactory results, and Mr. Pollard sprayed some plants with such a mixture to which 1% glycerine was added to keep it moist after application. The foliage of the plants was severely injured by the spray. The foliage of the experimental plants had been rendered sticky by sprays containing more than 5% sugar, and was definitely scorched by a 1% solution of sodium fluoride.

As it is unlikely that glycerine at a dilution of 1% or sugar at that of 3·5% would cause injury to foliage, the scorching was probably caused by the sodium fluoride. Further investigation is therefore necessary before any recommendation as to the use of such poison-baits can be made.

4. Insecticide & Fungicide Investigations.

W. H. Read.

1. Red Spider Mite.

The fear of causing *oedema* on young tomato plants by the application of petroleum oil emulsion sprays early in the season frequently induces growers to delay spraying operations for the control of red spider mite until the infestation becomes serious. The possibility of substituting derris insecticides for the petroleum oil emulsions now in general use has therefore been investigated. Many commercial derris sprays and dusts have been tried. Dusts containing derris were without appreciable action on the mite, but several sprays containing emulsified derris extracts, or finely ground derris, together with a wetting agent, shewed considerable toxicity to the mite in small scale trials conducted early in the season. Control of the pest was obtained in February by two applications of these sprays to badly infested cucumber and tomato plants.

Extended trials throughout the season, however, have shewn that a satisfactory control of the pest was unobtainable during the summer even if the same insecticides were applied at two or more times the strength found effective in the first instance. Consequently sprays containing derris as the active principle appear unlikely to replace petroleum oil emulsions for general use, and further work is necessary before they can be recommended for use early in the season when risk of *oedema* is greatest.

Many other insecticide preparations, which were claimed to kill red spider mite, have been tested in small scale spray trials, but of these one only was effective if refined petroleum emulsions are omitted.

This proved to be a sulphonated, oxidised petroleum mixture similar to one tested at this Station in 1930, and which was found more likely to cause *oedema* than petroleum oil emulsions.

Comparative tests as to the *oedema* promoting tendency of some of the most widely used petroleum oil emulsions have shewn that there are considerable differences in this respect when each is applied at the concentration necessary to give an effective control of the mite.

In view of the damage which has occasionally resulted from the fumigation of carnations with naphthalene to destroy red spider mite the problems connected with this control method are being investigated.

2. Tomato Leaf Mould and Cucumber Mildew.

The combined insecticide and fungicide mixture mentioned in the Nineteenth Annual Report (1933), which consisted of a proprietory "colloidal copper" together with a petroleum oil emulsion, has become widely adopted by growers. Consequently other fungicidal substances have been tried in combination with oil emulsions, including several samples of copper oxychloride, which is the active ingredient in the "colloidal" copper mentioned above. These substances have also been tried in conjunction with wetting agents as fungicides only. A brief résumé of the results obtained with some of the most promising of these substances may be of interest.

3. Copper oxychloride.

Many samples of copper oxychloride powder have been obtained from manufacturers. These varied considerably in chemical composition since the copper content varied from 49 to 54% and the chlorine content from 14·3 to 12·4%. The differences between their fungicidal efficiencies and their effects on plants were not sufficiently great, however, to enable any conclusions as to the relation between chemical constitution and fungicidal action to be obtained from spray trials. Good control of both tomato leaf mould and cucumber mildew was obtained by adding ½ ounce of copper oxychloride powder to a diluted oil emulsion, but results equal to those obtained with the proprietory copper oxychloride suspension required the addition of such quantities of copper oxychloride to the oil emulsion that the deposit on tomato and cucumber fruits was excessive. This is attributed to the larger particle size and poorer adhesion of the powdered copper oxychlorides which also tended to settle in the spray tank very much more rapidly than the colloidal product.

Employed in conjunction with wetting agents in the absence of petroleum oil emulsions these copper oxychlorides hardened the foliage of cucumbers when applied at fungicidal concentrations.

4. Copper salicylanilide *(Copper-Shirlan)*.

A paste containing this substance in an extremely fine state of division was kindly supplied by Imperial Chemical Industries, Ltd. When used at ¼ ounce per gallon with Agral N. at ⅛ ounce per gallon (or Agral 2 at $\frac{1}{12}$ ounce per gallon) this paste did not give such good control of cucumber

mildew or tomato leaf mould as can be obtained by the standard mixture of Shirlan H.B. and Agral N. recommended for the control of these fungi in the absence of red spider mite.

Severe leaf scorch, due to the presence of some salicylanilide which had not been converted to the copper salt, followed the application of mixtures of the copper-salicylanilide paste and petroleum oil emulsions. Samples of copper-salicylanilide have been treated in the laboratory to remove the oil soluble substances and further tests will be made with the resulting product.

5. Cuprous cyanide.

The fungicidal value of cuprous cyanide when applied with a wetting agent was poor; sprays containing 0·5% gave poor control of cucumber mildew and caused excessive deposits on the fruit. Although somewhat better results were obtained when cuprous cyanide was used at this strength in conjunction with an oil emulsion the marking of the fruit remained excessive.

In view of the desirability of a fungicide which will leave no visible deposit on fruit, additional tests have been made with oil soluble substances. The majority of these have shewn high fungicidal values when the solutions obtained by dissolving them in a refined petroleum suitable for spraying have been emulsified and employed as fungicides. In all cases severe injury resulted from their application at fungicidal concentrations.

Other solvents have been tried without success, and where it has been possible to apply the oil soluble substances to plants as suspensions containing a wetting agent their fungicidal value was not outstanding though they caused no injury to plants.

An investigation of the incompatibility of Shirlan H.B. and petroleum emulsion sprays has shown that the solubility of salicylanilide (i.e. Shirlan) in the petroleum amounting to 0·05% at 15°C. is responsible for the injury to plants. The petroleum oil used in these experiments was the same as that employed in an oil emulsion widely used for the control of red spider mite.

6. Other investigations.

Many recommendations for the control of "damping off" of seedlings have been published recently, and the majority of these have been investigated. In some cases the results obtained were inconclusive and the experiments are being

repeated. None of the treatments which were non-injurious to seedling growth, when employed immediately before sowing, proved effective in eliminating "damping off" caused by *Phytophthora cryptogea*.

A powder containing sodium cyanide and magnesium sulphate has been tried as a fumigant for the control of pests for which calcium cyanide or sodium cyanide and sulphuric acid are at present employed. This powder, one part of which is equivalent to 0·8 part of calcium cyanide or 0·5 part sodium cyanide, proved successful under glasshouse conditions when sprinkled on the floor or path provided the relative humidity was fairly high, i.e., above 70%, and the powder was evenly distributed.

7. Rose Rust.

The work of finding a suitable fungicide which when applied as a spray will control infections of *Phragmidium* has been pursued actively during the past year. These investigations are not easy because of the difficulty of growing heavily infected plants at the Station either in the glasshouse or in the open. This has been attributed to the presence of sulphur and other compounds in the atmosphere, and until proof has been obtained it is not advisable to give an opinion. It must, however, be noted that in gardens at Enfield, three or four miles from the Station but on the south-west side of the high land, rust infection occurs. The difference in "dew" formation is noteworthy, infection occurring where the deposition and length of duration is greatest.

Effective control of rust requires that the spore masses must be completely wetted. This penetration is not easily obtained, but as emulsified oils are excellent in this respect they have been used as carriers of fungicidal compounds.

The investigation has included the solution of certain compounds in oil followed by emulsification before use, and as an alternative the addition of fungicidal compounds to an emulsified oil.

Fungicides soluble in oil.

The copper in oil spray, of which mention is made in the "Rose Annuals" for 1934 and 1935, has been subjected to further tests against rose rust and rose mildew in the experimental rose house at Cheshunt. Under certain conditions, however, this spray caused a slight marking of the foliage which was undesirable, whilst a tendency to cause premature leaf-fall was suspected in the case of briars. Various modifications of this spray have been tried in an attempt to eliminate these disadvantages. The proportions of copper

compound (copper oleate) and oil (cottonseed oil) were varied, and other oils substituted for cottonseed oil, but in no case did an improved product result. An increase in the amount of emulsifying and wetting material (hydrolysed glue) reduced the marking of the foliage but diminished the fungicidal value. The original mixture of one part of copper oleate dissolved in two parts of cottonseed oil, followed by emulsification with three parts of a 20% solution of "hydrolysed" glue, finally proved best and it is unfortunate that it causes injury to the foliage.

Solutions of sulphur in a petroleum oil were emulsified and tested on roses. These emulsions shewed considerable fungicidal power in spite of the low solubility of sulphur in the oil but caused serious damage to the plants at fungicidal concentrations.

Other oil soluble substances have been tried, including compounds of copper, zinc, and mercury. Several oil soluble mercury compounds, kindly supplied by Messrs. Imperial Chemical Industries, shewed very great fungicidal action since germination of rust spores in hanging drop cultures was prevented by spraying the leaves with a spray containing one part of mercury in twenty thousand. It has been impossible so far to apply these compounds other than in oil solution.

In all cases plant injury resulted from the application of emulsified solutions of fungicides in oils, and as a result tests with such emulsions have been discontinued and experiments directed to sprays containing oil emulsions acting solely as "carriers" of fungicides which are insoluble in the oil.

Fungicides suspended in oil emulsions.

Of the many fungicides tested copper oxychloride was found to give the best control of rose mildew. Many samples of this compound were tried and the most effective proved to be a proprietory product in which copper oxychloride of extremely small particle size is suspended in paste form. This copper oxychloride mixture was found more effective when used with a petroleum oil emulsion than with a wetting agent since the oil caused the particles of fungicide to adhere to the fungus. Furthermore the mixture with an oil emulsion did not mark the foliage so much as the fungicide used with a wetting agent. As a result of these findings a combined copper oxychloride and petroleum emulsion is now marketed. Those who have difficulty in controlling attacks of rose mildew (*Sphaerotheca pannosa*) should make careful trials with this mixture* at a dilution of 1 ounce in 5 pints of water, for it has proved highly efficient in recent trials.

* Bouisol and White Oil Emulsion.

For use under glass where perfectly clean foliage is essential the addition of a modern synthetic wetting agent has proved advantageous, and many proprietory wetting agents have been found effective in spray trials at Cheshunt.

Unfortunately copper oxychloride mixtures have proved ineffective in the control of rose rust.

It is disappointing that despite all attempts to discover a reliable spray treatment for the rust disease of roses, success has so far eluded the investigators.

The work at Cheshunt has proceeded under great difficulties because heavy infestations on rose trees cannot be obtained under the natural conditions which exist either in glasshouses or in the open. Much work has been done in an attempt to discover why rust does not occur naturally in this district, and to devise means whereby the disease can be produced artificially, because such information would be useful to all rose growers. Means have been discovered for starting infections, but the intensity of the resulting attack is not sufficient to make spraying trials easy.

In conclusion we wish to record our grateful thanks to Mr. Courtney Page for his kind assistance in supplying diseased material for the investigations.

5. Chemical Investigations.

O. Owen.

1. General.

A feature of the work has been the large number of soil samples submitted for analysis at the end of the year. As a result, a number of subscribers waited some little time before the analytical results were available. It will help considerably if, in future years, growers will submit samples for analysis as soon after the end of the season as possible so that recommendations can be made in good time for the next season.

A number of samples of water were examined, but fewer than usual contained salt in any appreciable amount. In this connection it may be reported that a number of experiments have been carried out in search of some treatment which will minimize or remove the injurious effect of excess of salt in water and soils. We are still unable to advise any suitable treatment.

Queries continue to be received regarding the use of water softeners for nursery work. It is sometimes said that hard water may have undesirable effect if used for long periods on pot plants. When it operates this only applies to plants which are kept in pots for several years, such as those used for indoor decoration. In beds and borders in nurseries generally there is no evidence to show that hard water has any harmful effect, and it is unlikely that the use of water softeners under the conditions prevailing on the ordinary commercial nursery will prove of any advantage.

Of the samples of fertilizers examined only one calls for mention. This was a nitrogenous type, and the price at which it was offered was very considerably in excess of its manurial value.

2. Chlorate Weed-killers.

A number of cases of injury to young tomato plants have been traced again to the injudicious use of chlorates as weed-killers. For the first time injury to chrysanthemums was also traced to the same cause. Plants up to 2½ feet high had stopped growing: the leaves were pale grey-green in colour and shewed considerable distortion. It was found later that although the weed-killer had been used for some time with no ill effects on this particular nursery the pots containing the affected plants had been stood on ground immediately after the application of dry weed-killer.

Experiments shewed that the first effect of chlorate on chrysanthemums is to make the veins pale, then the leaf crinkles, distortion appears, and finally the whole leaf seems

to shrink and turn a peculiar greyish green colour. The effect on the plant is to cause stunting of the tops while the lower leaves may be quite normal in appearance.

Experiments with other plants indicate that the winter cherry is also very susceptible, possibly more so than the tomato. Dahlias are very slightly less susceptible than the winter cherry. The following details give an approximate idea of the relative susceptibilities of the different plants examined. In all cases when the plant had become well established in the pot it was "knocked out" and the inside of the pot washed with a dilute chlorate solution. The plant with the ball of soil was then replaced. The approximate amount in gms. of sodium chlorate so added, and of soil in the pots, are indicated in brackets.

Winter Cherry ...	24 hours—leaves wilting. 2 days—several leaves withered. 5 ,, plant dead. (·04/240)
Dahlia	24 hours—foliage darkened in colour. 2 days—practically all foliage badly scorched and desiccated. 5 days—plant practically dead. (·1/1150)
Antirrhinum	5 ,, practically no effect. (·04/240)
Broad Bean	2 days—one or two leaves badly distorted—reminiscent of leaf curl. 4 days—more general distortion and paling of foliage.
Nasturtium	2 days—older leaves very pale. 3 ,, ,, ,, almost white. 4 ,, desiccation of young leaves. 5 ,, serious scorch generally. Plants did not recover. (·04/240)
Wallflower	2 days—all veins pale grey. 5 ,, whitish mottle on upper leaves which lose colour generally. Lower leaves apparently dead. (·04/240)
Cinereria	2 days—very little effect. 5 ,, young leaves shew considerable distortion but little change in colour. Edges of older leaves desiccate and brown. (·04/240)
Aster	2 days—slight crinkling and paling of younger leaves 4 days—distortion and discolouration more definite. Waxlike appearance of younger leaves. Effect on veins and older leaves generally similar to "virus" effect. (·04/240)

Experiments with heaths indicate that they, like the antirrhinum, are comparatively resistant.

It will be seen that chlorates affect a wide range of plants and again it is necessary to emphasise the need for care in their use. Where pots or boxes have been contaminated they should be cleaned thoroughly before further use. When chlorate has been used on the open ground it is essential that it be washed in before any plants in boxes or in pots are stood out.

3. The potash content of the pulp of blotchy tomato fruit.

Further analyses of the pulp of the "blotchy" and "red" pulp of tomato fruits confirmed the findings reported last year, namely that "red" pulp contains rather more potash than "blotchy" pulp.

4. The effect of steaming on the "availability" of potash and phosphoric acid in tomato soil.

Steaming a tomato soil appears to increase but only very slightly the availability of phosphoric acid as measured by the solubility of the soil phosphate in 1% citric acid. The "availability" of potash appears to be definitely increased. Detailed results are shewn in the following table:—

Time	% Soluble in 1% Citric Acid. Potash (K_2O).	Phosphoric Acid (P_2O_5).
Before steaming...	·03278	·2484
3 hours after	·04656	·1933
24 hours after	·05139	·1882
2 days after	·04641	·2779
4 days after	·05466	·2972
5 days after	·04236	·3302
6 days after	·04758	·2353
8 days after	·04634	·2856
11 days after	·04749	·3456
13 days after	·06598	·3168
15 days after	·06354	·2395
18 days after	·06258	·3142

6. Physiological Investigations.

1. The movement of assimilate in seedling tomato plants.

B. D. Bolas and I. W. Selman.

In the course of work on the metabolism of seedling tomato plants, variety E.S.1, which is now in progress, some interesting observations on the movement of assimilate from the leaf system to the stem and root have been made.

It is well known that in a young plant the assimilate is moved from the mature leaves to the embryonic leaves, that is to say that some of the movement of the assimilate occurs from leaf to leaf, some of the assimilate on the other hand is moved out of the leaf system into the stem and root, thus providing for the growth and respiration of those parts of the plant which either do not carry out photosynthesis, such as the root, or in which photosynthesis is not sufficient to meet the demands of that part as in the stems, petioles, etc.

There has been in the past a tendency to consider that a large amount of assimilate is moved during the night, this view being largely based on the fact that if the leaves of a seedling plant are tested for starch at the end of an active day's assimilation, and again on the following morning, it is found that a loss in starch has taken place during the dark period, hence it has been considered that carbohydrates have been moved out of the leaves during the dark period. The fact of the reduction in the amount of starch in the leaf does not necessarily imply a transport of carbohydrate from the leaf, as the disappearance of starch may well be due to the formation of new leaf material during the dark period, this being associated with the utilisation of the starch and the uptake of water by the leaf.

If instead of observations of the starch content of the leaves, determinations are made of the dry weight of the stem root and leaves of similar plants at the beginning and end of an assimilation period, it is possible not only to calculate the amount of carbon assimilation that has taken place during that period but the distribution of the resulting carbohydrate. This method has been used by the Authors. The technical details have been discussed in other papers, but some of the more important results may be mentioned briefly.

It has been found that under ordinary cultural conditions the ratio of the dry weights of the various parts of a seedling tomato plant varies according to the time of year at which the

plant is grown. Thus the dry weights of the stem, root, and leaves of a plant having eight leaves in July, and of a plant having eight leaves in January, are given below, these weights being expressed as a percentage of the dry weight of the plant.

Dry weight of part expressed as percentage of total dry weight of plant.

	JULY. (Mean of 40 replicates.) Percentage gain in dry weight of plant in 7 hours=21.9. Mean Light Intensity =1,441 foot candles. Mean Temperature=78.8°F.	JANUARY. (Mean of 48 replicates. Percentage gain in dry weight of plant in 7 hours=10.2. Mean Light Intensity =150 foot candles. Mean Temperature=63.0°F.
Stem	23	33
Leaves	61	53
Root	16	14

The transition from conditions producing one type of plant to conditions producing the other is quite gradual, suggesting that the percentage of assimilate supplied to the various parts is almost proportional to the fraction that the dry weight of the part is of the dry weight of the plant. That the greater part of this distribution takes place during the assimilation period is suggested by the fact that there is but little change in the ratio of the weight of the plant parts between the beginning and end of the assimilation period. These are shewn below for the two experiments quoted.

Ratios of weights of plant parts at beginning and end of 7 hour assimilation period.

	JULY.		JANUARY.	
	9 a.m.	4 p.m.	9 a.m.	4 p.m
Stem	24	23	33	33
Leaves	60	62	54	53
Root	16	15	13	14

The distribution of dry matter during these assimilation periods is shewn below, the figures being based on the distribution of 100 gms. of dry matter and are derived from the gain in dry weight of the parts.

Distribution of 100 gms. of assimilate during assimilation period (9 a.m. to 4 p.m.).

	JULY.	JANUARY.
Stem	21%	29%
Leaves	69%	43%
Root	10%	28%

It will be seen that in summer, with a high assimilation rate, the leaf system which forms 61% of the dry weight of the plant has retained 69% of the assimilate, on a dry weight basis, at the end of the light period. If the form of the plant is to remain constant it should have retained 61%, that is to say 79·5% of the translocation out of the leaf system has taken place during the assimilation period. In winter, with a low assimilation rate, translocation during the light period is in excess of that required to maintain the existing ratio of the leaf system and the plant. That is to say that the stem and root are increasing in weight more rapidly than the leaf system. It will be seen that in winter the fraction of assimilate going to the root is relatively high, yet the root in the winter plant forms a slightly smaller fraction of the total dry material.

How far these differences are due to the low assimilation rates in the winter months and high assimilation rates in the summer, and how far they are due to other factors is not yet known.

The results would appear to justify the following inferences :—

(1) That the greater part of the movement of assimilate out of the leaf system into the stem and root occurs during the assimilation period and not, as has often been thought, during the night.

(2) That the respiration rate of the root is disproportionately high in winter.

2. A note on variation in growth rate in the tomato seedling.

D. W. Goodall.

It is a matter of common observation that a group of tomato plants from the same sowing, though treated alike during their growth, will nevertheless vary considerably in size by the time the first flower truss begins to develop. This variation is undesirable in physiological work, though it is seldom of sufficient magnitude to inconvenience the commercial grower. In an attempt to investigate this a group of tomato seedlings was measured at regular intervals for five weeks, from the four-leaf to the nine-leaf stage.

The most generally accepted measure of the growth rate of a plant is the rate of increase in dry weight. This, however, can be directly determined only by sampling, which is not

suitable for shewing up individual differences within a group of plants. But it was already known that the length of a leaf is closely related to its dry weight. Accordingly, rate of increase in leaf length was used as a measure of growth rate.

Since the growth rate of a leaf is continually changing throughout its development, for purposes of comparison of different plants it is necessary to determine it not at a given time but at a given leaf size. This was done for each of the first six leaves, and the mean of the growth rates of these leaves was taken to represent the growth rate of the plant as a whole. The values so obtained shewed great variation, the extremes being 60·2% and 124·5% of the mean for the group.

It was possible that these individual differences were largely due to local variations in temperature and illumination. This was tested in a group of seedlings by changing the positions of their pots on the staging of the greenhouse twice a week, in such a way that every plant passed through the whole range of environmental conditions two or three times during the course of the experiment. It was found that, though the variation in growth rates was slightly reduced by this treatment, it was still substantial:—

Co-efficient of variation, pot positions remaining constant = 16·14.

Co-efficient of variation, pot positions frequently changed = 15·55.

The difference between these figures would presumably be greater in a commercial greenhouse, where the local effect of the heating pipes would be more marked than in the rather cool house used for this experiment.

Differences in composition of the soil were negligible, since all the plants were potted up with a single well-mixed sample of compost. But another possible cause of differences in growth rate was variation in the amount of water available to the plants, due to chance differences in potting. This was investigated by measuring, for each pot, the time taken for a given volume of water to disappear into the soil, when the latter was already saturated. The drainage time thus obtained was presumably related to the amount of water remaining in each of the pots after they had been watered. No significant correlation, however, was found between drainage time and growth rate.

Therefore, it appears that most of the variation in growth rate must be due to internal factors. In view of the fact that Melville* found a relation between the assimilation rate of the tomato plant and its water content, it was considered desirable to find whether there was also a relation between water content and growth rate. When this point was investigated a highly significant positive correlation was found.

This fact indicates that the optimal water content for leaf growth during November and December is greater than 92·23%, the mean value for this group of plants. From a correlation diagram, it appears to be not less than 93·0%. Thus, there is some evidence that the optimum water content for leaf growth is higher than that for assimilation per unit leaf area, which Melville found to be about 92%; the significance of the difference between these figures, however, has not yet been investigated.

The high values of these optima are not in conflict with the commercial practice of keeping the water content of the plants fairly low, for the growth rate of the leaves bears no direct relation to fruit production.

The internal causes of variation in water content and growth rate are at present unknown. Though none of the plants used shewed any signs of disease, it may be that viruses affecting the metabolism were latent in some of them. On the other hand, the variation may well be due to genetic differences within the variety.

* Melville, R., Water Content and Assimilation of Seedling Tomato Plants. Cheshunt Research Station Annual Report, No. 19, pp. 87—92, 1933.

7. Miscellaneous.

O. B. Orchard.

Report of the Extension Officer.

The fungi causing "damping off" and "foot rot" were again responsible for considerable losses among young tomato plants, both in the propagating houses and after planting out. Growers are reminded that they run considerable risk of serious loss unless precautions are taken to ensure the use of clean soil, boxes, etc.

Attacks of *Verticillium wilt* were very prevalent amongst tomatoes and appeared earlier in the season than usual. The severity of attack by this fungus was no doubt largely due to the exceptionally early planting practised by many growers. Repeated experiments at this Station have shewn that when the soil temperature is less than 57°F. at a depth of 6 inches when tomatoes are planted out they are frequently attacked by *Verticillium alboatrum* and also the common root rot organisms.

The cucumber root fly maggot.

Attacks of the cucumber root fly maggot occurred on a large number of nurseries and the pest now appears to be established over a very wide area. Many experiments in the control of this pest have been conducted under commercial conditions. When the pest occurs on plants in pots, it has not been found possible to improve on the control methods suggested in the Eighteenth Annual Report of this Station, namely, the drenching of the soil with a nicotine-sulphonated oil preparation at a strength of 1 ounce in 3 gallons water. This preparation is also advised when only a small area of beds has to be treated, but when a very large area is involved this treatment becomes expensive. For such purposes an emulsion of tar acids is recommended. Growers desiring further information should apply to the Director for full particulars.

Caterpillars on cucumbers.

Injury by caterpillars (usually the tomato moth caterpillar) frequently occurs on cucumber plants shortly after planting out in the early spring. A number of experiments conducted during the past season shew that if control measures are adopted while the caterpillars are quite small they are readily killed by applications of insecticides containing pyrethrum.

Millepede control.

On many nurseries extensive damage has been caused by attacks of millepedes (*Blanjulus guttulatus* and *Orphomorpha gracillis*) to crops of cucumbers and mushrooms. The pest does not usually feed on healthy roots of cucumbers, but a number of cases have been observed where the pest has occurred in vast numbers and injury to healthy roots was noticed quite early in the season.

The pest feeds freely on mushrooms and renders them unsaleable. When this crop is grown in glasshouses, the pest frequently gains entrance from neighbouring cucumber houses. It is not advisable to use naphthalene continually on either mushroom beds or very young cucumbers, and further experiments have been conducted with a number of compounds for the control of this pest, when it occurs under the above conditions. A solution of nicotine at a strength of 1 part in 2,000 parts of water with the addition of a wetting agent such as Lethalate or Agral, used at the maker's recommended strength, has been found to give a more satisfactory control than nicotine alone at a strength of 1 part in 1,000 parts water. The solution should be applied by means of a watering can with a fine rose, or preferably a hand sprayer, covering the whole of the surface of either the mushroom or cucumber beds and paths. The pest feeds at the surface chiefly at night, and as the above solution kills mainly by contact it should be applied as late in the day as possible, using only a very small quantity of the solution.

Control measures against this pest should be commenced shortly after the heat has been applied to the houses and continued while the pest is in evidence. As the plants become harder the naphthalene treatment recommended in the Nineteenth Annual Report of this Station should be adopted.

APPENDIX A.

PUBLICATIONS.

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APPENDIX B.

Manurial Treatment in Tomato Experiments.

(1) Lime

All houses received ground caustic lime at the rate of 2 tons per acre.

(2) Stable Manure.

Houses 5, 6, 7 to 10, 11 and 12 received 15 tons horse manure per acre, except plots 1 to 4, house 2.

(3) Base-dressing.

House 5 and plots 5 to 8 in house 2 received ¾ lb. per square yard of the following mixture :—

1 part bone meal.
1 part bone flour.
1 part hoof and horn.
1 part sulphate of potash.

Houses 6, 7 to 10, 11 and 12 received ¾ lb. per square yard of the following mixture :—

1 part bone meal.
1 part bone flour.
1 part sulphate of potash.

Houses 1, 3 and 4, and also plots 1 to 4, house 2, received ¼ lb. sulphate of potash per square yard.

(4) Top-dressing.

SULPHATE OF POTASH.—All houses received a first top-dressing of sulphate of potash at the rate of 2 ozs. per square yard.

FERTILISER MIXTURE.—Houses 1, 2, 5 to 12 received 2 ozs. per square yard of the following mixture every 14 days *at discretion* :—

3 parts sulphate of potash.
2 parts dried blood.
7 parts 30% superphosphate.
5 parts pure dissolved bones.
½ part bone flour.
2½ parts sulphate of potash.

Houses 1, 2, 5, 6, 7 to 12 received three top-dressings of the following mixture at the rate of 2 ozs. per square yard :—

1 part sulphate of ammonia.
1 part nitrate of potash.
3 parts superphosphate.
5 parts dried blood.

APPENDIX C.

Manures applied to Plots 1-3, and 14-16 in Tomato Houses 3 and 4.

Plot.	TITLE.	Base Manure in Lbs. per sq. yd.				† Top-dressing in Lbs. per sq. yd.			
		Lime.	Stable Manure.	Basic Slag.	Sulphate of Potash.	Super-phosphate.	Sulph. of Ammonia.	Nitrate of Soda.	Sulph. of Potash.
1	Complete Artificials (I.) without Nitrogen	1.0	—	0.4	0.1	0.5	—	—	0.2
2	Unmanured	1.0	—	—	—	—	—	—	—
3	Complete Artificials	1.0	—	0.4	0.1	0.5	0.2	0.2	0.2
14	Complete Artificials with Dung	1.0	7	0.4	0.1	0.5	0.2	0.2	0.2
15	Complete Artificials without Phosphates	1.0	—	—	0.1	—	0.2	0.2	0.2
16	Complete Artificials without Potash	1.0	—	0.4	—	0.5	0.2	0.2	—

† The Top-dressing was applied in eight equal instalments.

Manurial Treatment in House 3, and Plots 4-13 in House 4.

Detailed in Diagram on page 18.

N = No nitrogen.

N_1 = 4 ounces hoof and horn per square yard.

N_2 = 8 ounces hoof and horn per square yard.

P = 4 ounces bone meal per square yard.

Appendix D.

Dates of Cultural Operations 1934—1935

Crop.	Sown.	Potted into 60's.	Potted into 32's.	Planted out in borders.	First Mulching.	First Top Dressing.	First Fruit Picked.	Last Fruit Picked.
Cucumbers	Dec. 6 1934	Dec. 18 1934	Dec. 31 1934	Jan. 17 1935	Feb. 20 1935	Feb. 28 1935	Feb. 27 1935	Sept. 2 1935
Tomatoes	Dec. 6 1934	Dec. 31 1934	——	Feb 12 1935	——	April 25 1935	May 7 1935	Oct. 11 1935

Month.	Air Temperatures						Grass Temp.			Rainfall				Mean Soil Temperatures		Hygrometer				Bright Sunshine		Barometer
	Mean		Absolute Max.		Absolute Min.		Av. Min.	Absolute Min.		Total Precipitation	No. of Days P'ptn.	Greatest Fall				Dry Bulb	Depres. of Wet Bulb	Relative Humidity %	Dew Point	Total No. of Hrs.	Daily Average.	
	Max.	Min.	Tem.	Date	Tem.	Date		Tem.	Date			Amt.	Date	1 ft.	2 ft.							
	°F.	°F.	°F.		°F.		°F.	°F.		Ins.		Ins.		°F.	°F.	°F.	°F		°F.			Ins.
January	45.3	34.9	54.0	1st	22.0	27th	30.9	16.0	27th	1.61	8	0.56	28th	42.1	43.5	34.6	1.4	85.5	36 6	53.9	1.7	30.25
February	51.0	37.6	67.0	22nd	26.0	8th	33.8	22.0	8th	2.44	14	0.55	24th	41.9	42.2	44.1	2.6	81.8	38.9	77.0	2.7	29.75
March	53.7	36.6	70.0	21st	28.0	8th	32.9	26.0	4th, 8th	0.52	5	0.23	23rd	42.3	43.6	45.9	2.0	85.2	41.5	99.0	3.2	30.13
April	57.1	39.5	65.0	20th, 30th	30.0	12th	36.1	26.0	12th	3.09	17	0.51	7th	47.1	47.6	51.0	3.8	74.7	39.3	98.1	3.3	29.76
May	63.4	42.5	84.0	10th	27.5	16th	39.2	24.0	16th	1.25	8	0.34	20th	52.4	52.2	55.4	5.3	69.4	44.8	221.8	7.2	30.09
June	72.3	51.7	86.0	24th, 25th	38.0	15th	48.2	37.0	15th	3.18	12	0.63	10th	60.7	59.6	66.1	3.8	76.4	56.5	177.5	5.9	29.87
July	69.2	52.2	87.0	15th	43.0	30th	47.7	38.0	30th	0.53	5	0.25	18th	65.7	64.5	70.9	7.0	66.5	58.8	302.7	9.8	30.13
August	77.4	51.2	91.0	22nd	40.0	27th	46.2	35.0	13th	1.37	6	0.57	30th	63.9	64.1	65.4	6.1	69.8	57.9	233.8	7.5	29.99
September	68.0	47.2	75.0	12th, 14th	35.0	25th	42.2	29.0	25th	3.71	19	0.58	24th	57.7	58.3	60.8	4.2	76.2	52 8	139.0	4.6	29.87
October	58.1	40.7	64.0	7th	25.0	20th	34.9	19.0	20th	3.42	14	1.35	3rd	50.9	52.3	52.9	2.8	89.0	47.5	101.5	3.2	29.81
November	51.8	38.3	63.0	3rd	22.0	25th	33.3	21.0	24th	3.96	20	0.68	16th	46.2	47.6	46.0	1.6	89.0	42.4	47.5	1.6	29.68
December	42.5	32.5	51.0	29th	20.0	22nd, 23rd	28.2	17.0	22nd, 23rd	2.30	14	0.70	26th	38.5	40.9	37.6	1.1	90.7	33.8	25.5	0.8	29.99

Total rain for year, 27.38 ins. No. of days precipitation, 142. Total bright sunshine for year, 1578.3 hours.

DIAGRAM SHEWING ARRANGEMENT OF EXPERIMENTAL PLOTS. 1935